DOCUMENT RESUME

ED 453 371 CE 081 768

AUTHOR	Knapp, John; Harper, Eddie
TITLE	Gas Metal Arc Welding and Flux-Cored Arc Welding. Third Edition. Teacher Edition [and] Student Edition [and] Student Workbook.
INSTITUTION	Multistate Academic and Vocational Curriculum Consortium, Stillwater, OK.
PUB DATE	2001-00-00
NOTE	450p.; Written by Clarence Fortney, Mike Gregory, and Larry New. Project coordinated by Cheryl Barr. For second edition of "Teacher Edition," see ED 348 487.
AVAILABLE FROM	Multistate Academic and Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, OK 74074-4364. (Teacher Edition: order no. 600401, $18; Student Edition: order no. 600402, $14; Student Workbook: order no. 600442, $25). Tel: 800-654-3988 (Toll Free); e-mail: mavcc@mavcc.com; Web site: http://www.mavcc.org.
PUB TYPE	Guides - Classroom - Learner (051) -- Guides - Classroom - Teacher (052)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Competency Based Education; *Course Content; Curriculum Guides; Education Work Relationship; Instructional Materials; *Job Skills; Learning Activities; Learning Modules; Lesson Plans; Postsecondary Education; Safety Education; Secondary Education; Teaching Guides; *Teaching Methods; Tests; *Welding; Workbooks
IDENTIFIERS	Crosswalks (Linking)

ABSTRACT

This packet, containing a teacher's edition, a student edition, and a student workbook, introduces students to high deposition welding and processes for "shielding" a weld. In addition to general information, the teacher edition consists of introductory pages and teacher pages, as well as unit information that corresponds to the materials in the student edition. The introductory pages include a training and competency profile, a state duty and task crosswalk, instructional and task analysis, basic skills icons and classifications, a basic skills matrix, and a list of tools, equipment, and materials. The teacher pages include suggested activities, answers to assignment sheets, a written test with answers, teacher supplements, and transparency masters. The student edition contains learning activities sheets, objective sheets, information sheets, and student supplements for the three units of the course. The student workbook contains assignment sheets and job sheets for the units. The three units covered by the course are Gas Metal Arc Welding (GMAW) Orientation and Safety; GMAW Equipment, Applications, and Techniques; and Flux-Cored Arc Welding. (KC)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 453 371

Gas Metal Arc Welding and Flux-Cored Arc Welding
Third Edition
Teacher Edition [and] Student Edition [and] Student Workbook

John Knapp and Eddie Harper

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY
A. Pratt
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
2B

CE 081 768

BEST COPY AVAILABLE

Gas Metal Arc Welding
and
Flux-Cored Arc Welding

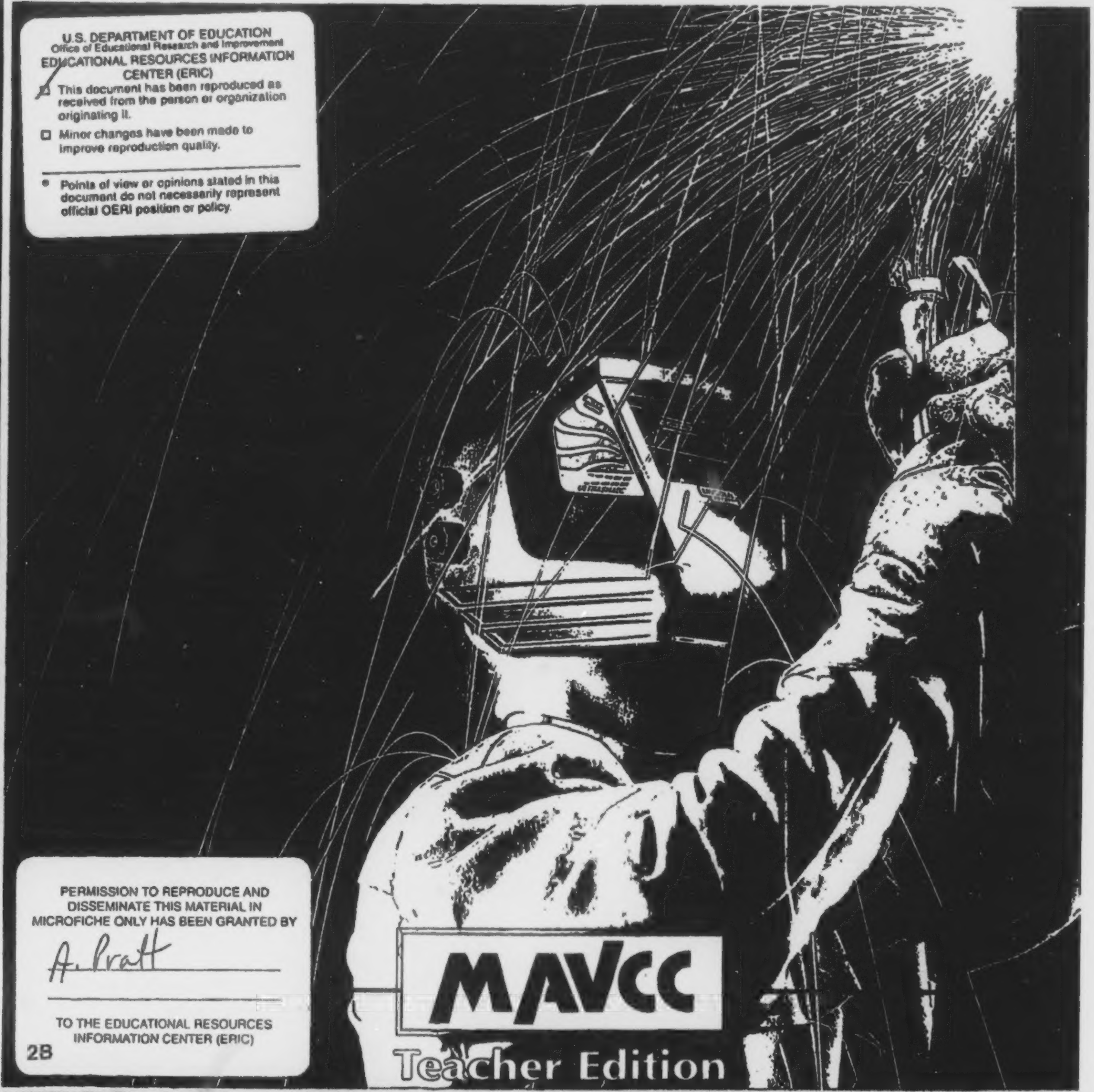
THIRD EDITION

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.



PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

A. Pratt

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2B

CE081168

MAVCC

Teacher Edition

Gas Metal Arc Welding
and
Flux-Cored Arc Welding

Third Edition

Teacher Edition

Written by

Clarence Fortney
Mike Gregory
and
Larry New

Revised by

John Knapp
and
Eddie Harper

Project coordinated by

Cheryl Barr

Developed by

The Multistate Academic and Vocational Curriculum Consortium, Inc.

Board of Directors

Mervin Birdwell, Louisiana, Chair
Dana Tannehill, Missouri, Vice Chair
Kimberly Sadler, Oklahoma, Parliamentarian
Ben Clay, Kansas
John Davidson, Arkansas
Larry Nelson, South Dakota
Lynne Cohen, Tennessee
Shirley Gantt, Georgia
Jim Fliehler, Iowa
David Closky, Pennsylvania
Bennie Walker, Texas

Clark R. Harris, Executive Director

01-014933
600401

©2001 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Cover art courtesy of Lincoln Electric Company.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Table of Contents

Introductory Pages

Foreword v
Acknowledgments vii
Use of this publication ix
Training and competency profile xvii
State of Oklahoma welding duty/task crosswalk xxi
Instructional/task analysis xxxv
Basic skills icons and classifications xli
Basic skills matrix lv
Tools, equipment, and materials list lvii

Units of Instruction

Unit 1: GMAW Orientation and Safety

Unit 2: GMAW Equipment, Applications, and Techniques

Unit 3: Flux-Cored Arc Welding

Foreword

Gas Metal Arc Welding and Flux-Cored Arc Welding introduces students to high deposition welding and processes for "shielding" a weld. Because of their speed and weld quality, GMAW and FCAW are popular processes with a variety of industries. Students who master these vital welding processes will enhance their employability skills.

Gas Metal Arc Welding and Flux-Cored Arc Welding, Third Edition retains a substantial amount of the first two editions of this publication. Definitions and symbols agree with AWS standards and include valuable troubleshooting information. New information and job sheets have been added on surface tension transfer and pulsed-spray transfer.

These instructional materials have been designed to assist teachers in improving instruction. Every effort has been made to make these materials basic, readable, and usable. The teacher will need to develop instructional strategies for motivating their students, and localizing, individualizing, and supplementing the instructional materials. Suggestions for teaching the unit, suggested supplemental resources including Internet resources, a criterion-referenced test, teacher supplements, and transparency masters are included in the teacher pages for each unit of instruction.

This edition of *Gas Metal Arc Welding and Flux-Cored Arc Welding* includes a student workbook that contains an assignment sheet for Unit 1 and job sheets for Unit 2 and Unit 3. Student workbooks can be purchased individually each year to provide new students with the assignment and job sheets needed to master the course.

MAVCC's welding series is crosswalked to the state of Oklahoma's welding duty/task list which is aligned to AWS standards.

Mervin Birdwell, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Clark R. Harris
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

Acknowledgments

Well-deserved thanks go to the many industry and education representatives who participated as members of MAVCC's welding committees through the years. Their assistance in developing and revising these instructional materials has been an essential step in MAVCC's development process.

Appreciation is also extended to those individuals who contributed their time and talent to the third revision of *Gas Metal Arc Welding and Flux-Cored Arc Welding*.

Paul Childers	Choctaw, OK
Charles Ehemann	Russellville, AR
Rick Gaffney	Sperry, OK
Eddie Harper	Tulsa, OK
Jim King	Burlington, IA
John Knapp	Tulsa, OK
Rick Massey	St. Charles, MO
Owen Smith III	Tulsa, OK
Terry Smith	Wichita, KS
Luke Steinmetz	Rapid City, SD
Gary Watts	Waverly, TN

A special thank you to the following companies for providing illustrations that appear in this publication:

Lincoln Electric Company, Cleveland, Ohio
American Welding Society, Miami, Florida
Praxair, Inc., Danbury, Connecticut
Tweco, Wichita, Kansas

Special thanks to Lincoln Electric Company for providing materials and assistance.

Appreciation is also extended to the employees of the Graphics Division of the Oklahoma Department of Career and Technology Education for printing this publication.

Thanks are also extended to Jane Huston, MAVCC Director of Development.

Use of This Publication

Gas Metal Arc Welding and Flux-Cored Arc Welding is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the welding advisory committee, comprised of business/industry representatives and teachers. Competencies align with the welding duty/task list developed by the state of Oklahoma.

Teacher Edition

The teacher edition consists of introductory pages and teacher pages. It is recommended that the instructor purchase the student edition and student workbook for a complete teacher edition. The introductory and teacher pages are loose-leaf and three-hole punched. The student edition is spiral-bound, and the student workbook is perfect-bound with the pages perforated for easy removal. Each are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit in the teacher edition is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Examples:

Page 17 of Unit 3 in the teacher pages is represented as T 3–17.

MAVCC—*Gas Metal Arc Welding and Flux-Cored Arc Welding* T 3–17

Pages in the student workbook are numbered sequentially beginning with page 1.

MAVCC—*Gas Metal Arc Welding and Flux-Cored Arc Welding* Page 1

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

MAVCC—*Gas Metal Arc Welding and Flux-Cored Arc Welding* Page 5–7

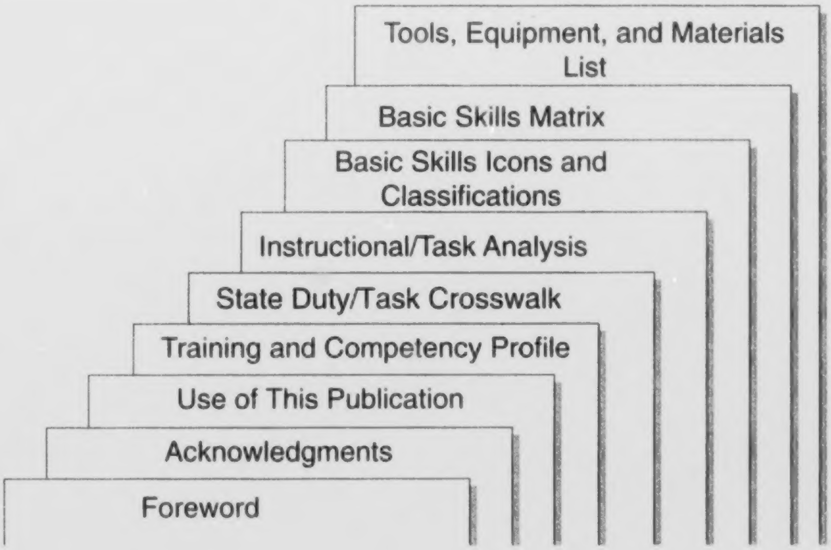
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
State Duty/Task Crosswalk
Training and Competency Profile
Use of This Publication
Acknowledgments
Foreword

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

☐ **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

☐ **State Duty/Task Crosswalk.** This document identifies the state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective or assignment and/or job sheet.

☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

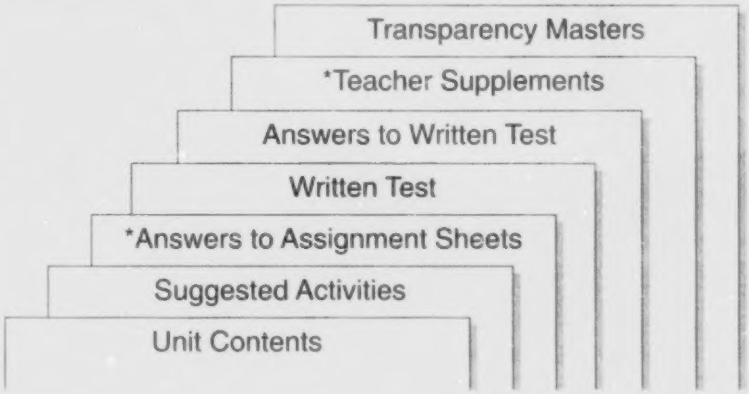
☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each assignment sheet and job sheet.

☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

☐ **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Use of This Publication

Teacher Pages



*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

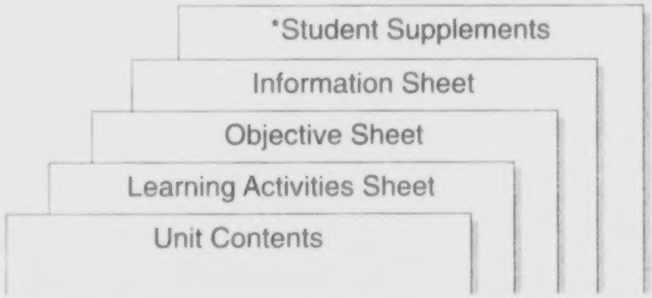
Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

Use of This Publication

☐ **Learning Activities Sheet.** This component can be used to guide the student in self-paced or individualized programs, and in other programs provides the student with an overview of how components interface within the unit. It's designed to guide the student through the required and optional components in the student edition (objective sheet, information sheet, student supplements) and through the assignment sheets and job sheets located in the student workbook. The teacher is encouraged to use this component as a model and modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, or journal article

🖥 Use a CBT program or other software application

WWW Access a site on the World Wide Web

🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

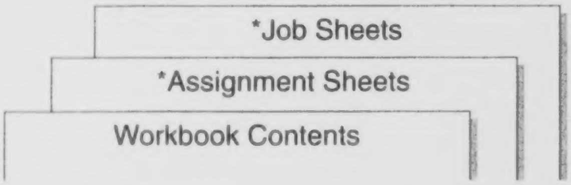
The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

Student Workbook



*Designates components that may not appear in every unit of instruction

The student workbook is an integral part of the student materials and should be provided to each student. It contains the pen-and-paper exercises and skill tests necessary for student mastery of the course.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

Use of This Publication

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or e-mail us at mavcc@mavcc.com.

Gas Metal Arc Welding and Flux-Cored Arc Welding

Training and Competency Profile

Student Information

Program ______________________ Instructor ______________________

Name ______________________ Soc. Sec. No. ______________________

Address ______________________ Phone ______________________

Grade ______________ School ______________________

Allergies/Disabilities that might require special accommodation for training (please specify)

____

In case of emergency, contact ______________________ Phone ______________

Record of Enrollment

Date of Enrollment ___-___-___ Total Class Hours ______ Total Hours Absent ______

Date of Withdrawal ___-___-___ Total On-the-Job Training Hours ______ Total Hours Tardy ______

Date of Completion ___-___-___ Total Lab Hours ______

On-the-Job Training/Work Experience

______________________ ______________________

Place of Employment Address

______________________ ______________________

Supervisor's Name Phone

______________________ ______________________

Duration of Employment Job Title

____

Job Responsibilities

______________________ ______________________

Place of Employment Address

______________________ ______________________

Supervisor's Name Phone

______________________ ______________________

Duration of Employment Job Title

____

Job Responsibilities

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4	Skilled—Can perform job with no additional training
3	Moderately Skilled—Has performed job during training program; limited additional training may be required.
2	Limited Skill—Has performed job during training program; additional training is required to develop skill.
1	Unskilled—Is familiar with process, but is unable to perform job.
0	No Exposure—No information or practice provided during training program, complete training required.
NA	Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

Unit 1: GMAW Orientation and Safety

________ 1. Solve problems concerning GMAW safety.
________ 2. ________________________________
________ Written Test Score

Unit 2: GMAW Equipment, Applications, and Techniques

________ 1. Set up wire on a GMAW wire feeder.
________ 2. Set up a flow meter and regulator for a GMAW shielding gas.
________ 3. Set up GMAW equipment for short-circuit transfer on mild steel.
________ 4. Prepare mild steel for GMAW.
________ 5. Use short-circuit transfer to lay stringer beads and build a pad on mild steel in the flat position.
________ 6. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position.
________ 7. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position.
________ 8. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position.
________ 9. Perform a guided-bend test on a welded V-groove butt joint.
________ 10. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position.
________ 11. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position.
________ 12. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position.
________ 13. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position.
________ 14. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the vertical position.
________ 15. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position.
________ 16. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position.
________ 17. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position.
________ 18. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position.
________ 19. Set up GMAW equipment for spray transfer on mild steel.
________ 20. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position.
________ 21. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position.
________ 22. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position.
________ 23. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position.
________ 24. Use spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position.
________25. Set up GMAW equipment for spray transfer on aluminum.
________ 26. Prepare aluminum for GMAW.

________ 27. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position.

________ 28. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position.

________ 29. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position.

________ 30. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position.

________ 31. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position.

________ 32. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position.

________ 33. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position.

________ 34. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position.

________ 35. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position.

________ 36. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position.

________ 37. Set up GMAW-P equipment for pulsed-spray transfer on mild steel.

________ 38. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position.

________ 39. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position.

________ 40. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position.

________ 41. Set up STT equipment for surface tension transfer on mild steel.

________ 42. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the flat position.

________ 43. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position.

________ 44. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position.

________ 45. ____________________________

________ Written Test Score

Unit 3: Flux-Cored Arc Welding

________ 1. Set up or replace wire on a flux-cored wire feeder.

________ 2. Set up FCAW equipment for semiautomatic flux-cored welding.

________ 3. Prepare mild steel for FCAW.

________ 4. Weld to specifications a fillet weld lap joint on mild steel in the flat position.

________ 5. Weld to specifications a fillet weld T-joint on mild steel in the flat position.

________ 6. Weld to specifications a fillet weld lap joint on mild steel in the horizontal position.

________ 7. Weld to specifications a fillet weld T-joint on mild steel in the horizontal position.

________ 8. Weld to specifications a fillet weld lap joint on mild steel in the vertical position.

________ 9. Weld to specifications a fillet weld T-joint on mild steel in the vertical position.

________ 10. Weld to specifications a fillet weld lap joint on mild steel in the overhead position.

________ 11. Weld to specifications a fillet weld T-joint on mild steel in the overhead position.

________ 12. Weld to specifications a V-groove butt joint on mild steel in the flat position.

________ 13. Weld to specifications a V-groove butt joint on mild steel in the horizontal position.

________ 14. Weld to specifications a V-groove butt joint on mild steel in the vertical position.

________ 15. Weld to specifications a V-groove butt joint on mild steel in the overhead position.

________ 16. ____________________________

________ Written Test Score

Gas Metal Arc Welding and Flux-Cored Arc Welding

State of Oklahoma Welding Duty/Task Crosswalk

The following state of Oklahoma welding tasks, which are aligned to AWS standards, are covered in this publication. The first column identifies Oklahoma's task by name and number. The second column identifies the exact location by unit number and objective, assignment sheet, or job sheet in this MAVCC publication unless otherwise noted.

Occupation: Gas Metal Arc Welder	MAVCC Tasks
Duty A: Demonstrate Employability Skills	
A.18 Identify employment opportunities	*Fundamentals of Welding*, Unit 1, Objective 7—Job outlook for welders; Objective 9—Career opportunities for welders; Assignment Sheet 2—Compare employment opportunities in welding
A.19 Identify levels of training recommended for related careers	*Fundamentals of Welding*, Unit 1, Objective 8—What it takes to become a good welder
A.20 Understand salary, wages and benefits packages	*Fundamentals of Welding*, Unit 1, Objective 6—What welders earn
Safety	
A.26 Explain the purpose for safety policies	*Fundamentals of Welding*, Unit 2, Objective 4—Hazard communication; Assignment Sheet 1—Complete the student safety pledge form; Assignment Sheet 5—Identify and correct safety violations
A.27 Discuss the role of OSHA and EPA — Locate information in MSDS	*Fundamentals of Welding*, Unit 2, Objective 6—Purposes of material safety data sheets; Student Supplement 1—Guidelines for interpreting material safety data sheets; Assignment Sheet 2—Interpret a material safety data sheet
A.28 Participate in OSHA training, if possible — Lock Out/Tag Out	*Fundamentals of Welding*, Unit 2, Objective 8—Safety tags and their color coding; Objective 19—Instances when lockout devices should be used
— HAZCOM	*Fundamentals of Welding*, Unit 2, Objective 4—Hazard communication
- MSDS	*Fundamentals of Welding*, Unit 2, Objective 6—Purposes of MSDS; Student Supplement 1—Guidelines for interpreting MSDS; Assignment Sheet 2—Interpret a material safety data sheet

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	MAVCC Tasks
— Bloodborne Pathogens	*Fundamentals of Welding*, Unit 3, Objective 18—Basic first-aid procedures for various emergency situations
A.29 Explain the proper steps in reporting an accident or emergency	*Fundamentals of Welding*, Unit 3, Objective 16—General steps for handling any emergency situation; Objective 17—General guidelines for first aid emergencies; Assignment Sheet 1—Determine basic first aid measures for given emergency situations
A.30 Explain the hazards associated with specific types of equipment and tools	*Fundamentals of Welding*, Unit 2, Objective 3—General job and shop safety rules; Assignment Sheet 5—Identify and correct safety violations *GMAW/FCAW*, Unit 1, Objective 10—Rules for handling hollow casting or containers; Objective 11—Hazards associated with arc rays
A.31 Perform machine operator safety checks of equipment and accessories, when necessary	*Fundamentals of Welding*, Unit 2, Assignment Sheet 5—Identify and correct safety violations; Unit 4, Objective 21—Basic rules for safe use of power tools and equipment
A.32 Practice tool safety	*Fundamentals of Welding*, Unit 2, Objective 3d—Tool use, maintenance, and storage safety; Unit 3, Objective 9—Rules for handling welding cables and gas and coolant hoses; Unit 4, Objective 20—Rules for hand tool safety; Objective 21—Basic rules for safe use of power tools and equipment; Objective 22—Rules for tool and equipment maintenance
A.33 Describe the types of fire hazards found in the workplace	*Fundamentals of Welding*, Unit 2, Objective 10—Components of fire triangle; Objective 11—Types of fires and classifications; Objective 12—Types of fire extinguishers; Objective 13—Fire extinguisher markings and class of fire they represent; Objective 14—Fire extinguisher operating instructions that follow P-A-S-S; Student Supplement 2—Using Portable Fire Extinguishers; Assignment Sheet 4—Determine correct fire extinguishers to use for various situations; Job Sheet 1—Operate a fire extinguisher

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	**MAVCC Tasks**
A.34 Discuss electrical hazards	*Fundamentals of Welding*, Unit 2, Objective 3f—Electrical safety; Unit 3, Objective 19—Treating a victim of electrical shock *GMAW and FCAW*, Unit 1, Objective 7—Electrical safety requirements for GMAW
A.35 Demonstrate safe use of personal protective equipment	*Fundamentals of Welding*, Unit 2, Objective 20—Fall protection systems; Objective 21—Confined space entry; Objective 22—Environmental contaminants that would require you to use a respirator *GMAW and FCAW*—Unit 1, Objective 12—Types of welding hoods; Objective 13—Guidelines for selecting a safe lens shade for GMAW; Objective 14—Protective clothing required for GMAW welding; Objective 15—Environmental safety requirements; Objective 16—Safety guidelines for working with electrode wire
A.36 Demonstrate safe material handling techniques — Lifting — Transporting — Storing	*Fundamentals of Welding*, Unit 2, Objective 15—Causes of back injuries; Objective 16—Guidelines for lifting and moving items safely; Job Sheet 2—Lift a heavy object properly
A.37 Understand established first aid procedures	*Fundamentals of Welding*, Unit 3, Objective 16—General steps for handling any emergency situation; Objective 17—General guidelines for first aid emergencies; Objective 18—Basic first-aid procedures for various emergency situations; Student Supplement 2—A Systematic Look at First Aid; Assignment Sheet 1—Determine basic first aid measures for given emergency situations
A.38 Practice good housekeeping	*GMAW and FCAW*—All job sheets require students to clean up their work areas and return tools and equipment to proper storage.
A.39 Comply with company safety policies	*Fundamentals of Welding*, Unit 2, Assignment Sheet 1—Complete the student safety pledge form

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	MAVCC Tasks
Basic Academic Skills	
A.40 Apply mathematical operations involving whole numbers, fractions, decimals, percentages, mathematical word problems, ratios, etc., when necessary — Addition — Subtraction — Multiplication — Division	*Fundamentals of Welding*, Unit 6, Assignment Sheet 1—Add, subtract, multiply, and divide fractions; Assignment Sheet 2—Add, subtract, multiply, and divide decimal equivalents; Assignment Sheet 3—Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms; Assignment Sheet 4—Write fractions as decimals and percents; Assignment Sheet 6—Write decimals as fractions and percents; Assignment Sheet 8—Make conversions with an inches-to-decimal conversion chart
A.41 Apply advanced mathematical operations, when necessary — Algebra — Geometry — Trigonometry — Calculus — Statistical Methods	*Fundamentals of Welding*, Unit 6, Objective 8, Terms used in geometry; Objective 9—Types of geometric figures; Objective 12—Area of geometric figures; Assignment Sheet 14—Calculate area of geometric figures; Job Sheet 1—Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor; Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock
A.42 Apply scientific principles, when necessary — Physics — Chemistry	*Fundamentals of Welding*, Unit 5, Objective 4—Metal identification tests; Objective 5—Mechanical properties of metals; Objective 6—Types of mechanical strengths; Objective 7—Physical properties of metals; Job Sheet 1—Conduct magnet tests to identify common metals used for welding; Job Sheet 2—Conduct chisel tests to identify common metals used for welding; Job Sheet 3—Conduct spark tests to identify common metals used for welding
A.43 Interpret charts, table, and graphs	*Fundamentals of Welding*, Unit 6, Assignment Sheet 7—Make conversions with a decimal equivalent chart; Assignment Sheet 8—Make conversions with an inches-to-decimal conversion chart
A.44 Apply reading and writing skills, when necessary	Most assignment sheets require the student to read and write.

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	MAVCC Tasks
Blueprint Reading	
A.50. Identify basic elements of blueprints — Terms — Components — Symbols	*Fundamentals of Welding*, Unit 7, "Welding Print Reading" *Fundamentals of Welding*, Unit 7, Objective 1—Terms related to print reading; Objective 2—Basic lines; Objective 13—Symbols
A.51 Discuss different types of drawings	*Fundamentals of Welding*, Unit 7, Objective 4—Isometric and oblique drawings
A.52 Interpret drawings — Bill of Materials — Revisions — Tolerances	*Fundamentals of Welding*, Unit 7, Objective 4—Isometric and oblique drawings; Objective 6—Tolerancing; Objective 15—Requirements for a formal bill of material; Objective 16—Requirements for an informal bill of material; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees; Unit 8, Assignment Sheet 5—Interpret a welding print and welding procedure specifications
A.53 Interpret symbols	*Fundamentals of Welding*, Unit 7, Objective 13—Symbols
Measurement Tools and Techniques	
A.54 Identify types of measuring instruments	*Fundamentals of Welding*, Unit 6, Objective 6—Types of rules and examples of their graduations
A.55 Use appropriate measurement instrument for a measurement task	*Fundamentals of Welding*, Unit 6, Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock
A.56 Read measuring instruments	*Fundamentals of Welding*, Unit 6, Objective 7—Steps in reading a rule; Assignment Sheet 9—Measure distances with 1", 1/2" and 1/4" graduations; Assignment Sheet 10—Measure distances with 1/4" and 1/8" graduations; Assignment Sheet 12—Measure distances with 1/16" graduations; Job Sheet 1—Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor; Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	MAVCC Tasks
A.57 Identify the appropriate formula and units for a measurement task	*Fundamentals of Welding*, Unit 6, Objective 11—Squares, rectangles, and triangles and their formulas for calculating their perimeters; Objective 12—Area of geometric figures
A.58 Differentiate between English and Metric measurement systems, when necessary	*Fundamentals of Welding*, Unit 6, Objective 13—English-metric conversion charts and how to use them; Assignment Sheet 13—Make conversions with an English-metric conversion chart
A.59 Communicate measurements using proper symbols or words	*Fundamentals of Welding*, Unit 6, Objective 10—Units of measure and their equivalents
Duty B: Interpret Drawing and Welding Symbols and Written Welding Procedures	
B.01 Interpret basic elements of drawing/ sketch	*GMAW and FCAW*—Unit 2, Job Sheets 5 through 8, 10 through 18, 20 through 24, 27 through 36, 38 through 40, 42 through 44; *Fundamentals of Welding*, Unit 7—Welding Print Reading (entire unit)
— Structural members	*Fundamentals of Welding*, Unit 7, Objective 14—Structural shapes
— Sequence of assembly	*Fundamentals of Welding*, Unit 7, Assignment Sheet 8—Construct adjacent parts in an assembly section
— Dimensions and tolerances	*Fundamentals of Welding*, Unit 7, Objective 5—Dimensioning; Objective 7—Methods of dimensioning; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees
— Scale	*Fundamentals of Welding*, Unit 7, Objective 9—Reduction and enlargement scales
— View interpretation	*Fundamentals of Welding*, Unit 7, Objective 3—Basic views; Objective 12—Types of section views; Student Supplement 2—Orthographic projection; Assignment Sheet 1—Construct a top view; Assignment Sheet 2—Construct a front view; Assignment Sheet 3—Construct a right side view; Assignment Sheet 7—Make a three-view sketch

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	MAVCC Tasks
— List of materials	*Fundamentals of Welding*, Unit 7, Objective 15—Requirements for a formal bill of materials; Objective 16—Requirements for an informal bill of materials
B.02 Interpret welding symbol information — Type of weld required — Filler metal — Special details — Non-destructive testing requirements	*GMAW and FCAW*—Unit 2, Job Sheets 5 through 8, 10 through 18, 20 through 24, 27 through 36, 38 through 40, 42 through 44 *Fundamentals of Welding*, Unit 8, Basic Welding Joints and Symbols (entire unit)
B.03 Interpret written welding procedures — Procedure ID number cross-referencing to drawing — Appropriate welding process/base materials/filler materials — Appropriate machine settings	GMAW and FCAW—Unit 2, "GMAW Equipment, Applications, and Techniques"—All job sheets
Duty D: Perform Gas Metal Arc Welding (GMAW)	
D.01 Perform safety inspections of equipment and accessories — Protective clothing — Equipment, accessories, and hand tools — Single or mixed shielding gas supply — Work area — Communicate hazard warnings to others	*GMAW and FCAW*, Unit 2—All job sheets require students to practice safety precautions. *Fundamentals of Welding*, Unit 2, "General Safety" and Unit 3, "Welding Safety and First Aid" cover safety in detail.
D.02 Make minor external repairs to equipment and accessories (preventative maintenance only) — Manufacturer's recommendations — Company repair policy — Equipment troubleshooting - Birdnesting - Porosity - Gas leaks	*GMAW and FCAW*, Unit 2, Objective 11—Preventive maintenance requirements for wire feeders; Objective 25—Conditions that require special attention with GMAW; Objective 26—Possible causes and corrective actions for undercutting; Objective 27—Causes and corrective actions for porosity; Objective 28—Causes and corrective actions for incomplete fusion; Objective 29—Causes and corrective actions for incomplete joint penetration; Objective 30—Causes and corrective actions for excessive melt-through; Objective 33—Guidelines for troubleshooting GMAW problems; Student Supplement 7—GMAW/Microprocessor Troubleshooting

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	**MAVCC Tasks**
D.03 Set up for gas metal arc welding operations on plain carbon steel plate — ER70S-X electrodes — Filler metal selection — Proper hand tool selection — Adjust voltage and polarity — Set wire speed — Proper gas flow rate — Parts set up and preheated as necessary — Review appropriate weld — Base metal preparation	*GMAW and FCAW*, Unit 2, Job Sheet 1—Set up wire on a GMAW wire feeder; Job Sheet 2—Set up a flow meter and regulator for a GMAW shielding gas; Job Sheet 3—Set up GMAW equipment for short-circuit transfer on mild steel
D.04 Operate gas metal arc welding equipment — Short circuit transfer (flat, single pass, multi-pass, multi-directional) fillet weld of plain carbon steel in all positions	*GMAW and FCAW*, Unit 2, Job Sheet 6—Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position; Job Sheet 7—Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position; Job Sheet 10—Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position; Job Sheet 11—Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position; Job Sheet 13—Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position; Job Sheet 14—Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the vertical position; Job Sheet 16—Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position; Job Sheet 17—Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position
— Short circuit transfer (flat, single pass, multi-pass, multi-directional) groove weld of plain carbon steel in all positions	*GMAW and FCAW*, Unit 2, Job Sheet 8—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position; Job Sheet 12—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position; Job Sheet 15—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position; Job Sheet 18—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	**MAVCC Tasks**
— Spray transfer (flat, single pass, multi-pass, and multi-directional) fillet weld of plain carbon steel plate	*GMAW and FCAW*, Unit 2, Job Sheet 20—Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position; Job Sheet 21—Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position; Job Sheet 22—Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position; Job Sheet 23—Use spray transfer to weld to specifications a fillet T-joint on mild steel in the horizontal position
— Spray transfer (flat, single pass, multi-pass, and multi-directional) groove weld of plain carbon steel in 1G position	*GMAW and FCAW*, Unit 2, Job Sheet 24—Use spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position
Short Circuit Transfer	
D.05 Make fillet welds, all positions, on plain carbon steel in 2F position—flat, multiple pass, multi-directional, surfacing welds	See job sheets listed under D.04, short-circuit transfer fillet weld of plain carbon steel in all positions.
D.06 Make groove welds, all positions, on plain carbon steel plate with backing in 1G(R) without backing	See job sheets listed under D.04, short-circuit transfer groove weld of plain carbon steel in all positions.
Spray Transfer	
D.07 Make 1F-2F welds on plain carbon steel plate — Flat, multi-directional — .035 or .045 diameter E70S-X electrodes — Argon/2%–5% Oxygen shielding gas	See job sheets listed under D.04, spray transfer fillet weld of plain carbon steel plate.
D.08 Make 1G welds on plain carbon steel plate with backing	*GMAW and FCAW*, Unit 2, Job Sheet 24—Use spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position
Duty G: Perform Manual Oxyfuel (OF) Cutting—Refer to *Oxyacetylene Welding and Cutting* for this duty.	
Duty I: Perform Air Carbon Arc Cutting (Gouging)—Refer to *Shielded Metal Arc Welding* for this duty.	

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Gas Metal Arc Welder	**MAVCC Tasks**
Duty J: Perform Plasma Arc Cutting and Gouging—Refer to *Gas Tungsten Arc Welding and Plasma Arc Cutting,* Unit 3, "Plasma Arc Cutting," for this duty.	
Duty K: Perform Welding Inspection and Testing	
K.01 Examine cut surfaces and edges of prepared base metal parts — Appearance — Uniformity — Proper fit-up — Base metal preparation	Every job sheet in Unit 2 of *GMAW and FCAW* (with the exception of Job Sheets 1 through 4, Job Sheet 19, Job Sheets 25 and 26, Job Sheet 37, and Job Sheet 41) requires the student to prepare plates and inspect welds.
K.02 Examine tack, intermediate layers, and completed welds	*GMAW and FCAW*—Unit 2, Job Sheets 5 through 8, 10 through 18, 20 through 24, 27 through 36, 38 through 40, 42 through 44
— Visual check for weld discontinuity and defects to an acceptable criteria — Destructive or non-destructive examination	*GMAW and FCAW,* Unit 2, Job Sheet 8—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position; Job Sheet 9—Perform a guided-bend test on a welded V-groove butt joint; Job Sheet 12—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position; Job Sheet 15—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position; Job Sheet 18—Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position; Job Sheet 24—Use spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position; Job Sheet 38—Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position; Job Sheet 39—Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position; Job Sheet 40—Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position; Job Sheet 42—Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the flat position; Job Sheet 43—Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position; Job Sheet 44—Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Flux-Cored Arc Welder	**MAVCC Tasks**
Duty A: Demonstrate Employability Skills—Refer to page xxi of this crosswalk for these tasks. **Safety**—Refer to page xxi of this crosswalk for these tasks. **Basic Academic Skills**—Refer to page xxiv of this crosswalk for these tasks. **Blueprint Reading**—Refer to page xxv of this crosswalk for these tasks. **Measurement Tools and Techniques**—Refer to page xxv of this crosswalk for these tasks.	
Duty B: Interpret Drawing and Welding Symbols and Written Welding Procedures	
B.01 Interpret basic elements of drawing/ sketch	*GMAW and FCAW*, Unit 3—Job Sheets 4 through 15 *Fundamentals of Welding*, Unit 7—Welding Print Reading (entire unit)
— Structural members	*Fundamentals of Welding*, Unit 7, Objective 14—Structural shapes
— Sequence of assembly	*Fundamentals of Welding*, Unit 7, Assignment Sheet 8—Construct adjacent parts in an assembly section
— Dimensions and tolerances	*Fundamentals of Welding*, Unit 7, Objective 5—Dimensioning; Objective 7—Methods of dimensioning; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees
— Scale	*Fundamentals of Welding*, Unit 7, Objective 9—Reduction and enlargement scales
— View interpretation	*Fundamentals of Welding*, Unit 7, Objective 3—Basic views; Objective 12—Types of section views; Student Supplement 2—Orthographic projection; Assignment Sheet 1—Construct a top view; Assignment Sheet 2—Construct a front view; Assignment Sheet 3—Construct a right side view; Assignment Sheet 7—Make a three-view sketch
— List of materials	*Fundamentals of Welding*, Unit 7, Objective 15—Requirements for a formal bill of materials; Objective 16—Requirements for an informal bill of materials
B.02 Interpret welding symbol information — Type of weld required — Filler metal — Special details — Non-destructive testing requirements	*GMAW and FCAW*—Unit 3, Job Sheets 4 through 15 *Fundamentals of Welding*, Unit 8, Basic Welding Joints and Symbols (entire unit)

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Flux-Cored Arc Welder	MAVCC Tasks
B.03 Interpret written welding procedures — Procedure ID number cross-referencing to drawing — Appropriate welding process/base materials/filler materials — Appropriate machine settings	GMAW and FCAW—Unit 3, "Flux-Cored Arc Welding"—All job sheets
Duty E: Perform Flux-Cored Arc Welding	
E.01 Perform safety inspections of equipment and accessories — Protective clothing — Equipment and hand tools — Equipment and accessories — Shielding gas equipment and accessories — Work area	*GMAW and FCAW,* Unit 3, Objective 16—Safety requirements for FCAW; All job sheets require students to practice safety precautions. *Fundamentals of Welding,* Unit 2, "General Safety" and Unit 3, "Welding Safety and First Aid" cover safety in detail.
E.02 Make minor external repairs to equipment & accessories (preventative maintenance only) — Manufacturer's recommendations — Company repair policy — Equipment troubleshooting - Birdnesting - Worm-holing - Porosity - Gas leaks	*GMAW and FCAW,* Unit 3, Objective 11—Guidelines for using drive rolls and guide tubes; Objective 17—Guidelines for troubleshooting FCAW problems; Student Supplement 4—FCAW Troubleshooting
E.03 Set up for flux cored arc welding operations on plain carbon steel plate — Mixed (75% argon/25% CO_2) or single (CO_2) shielding gas supply — E71T-X (gas-shielded) and E71T-X (self-shielded) electrodes (.045 minimum) — Review appropriate weld procedures — Base metal preparation — Filler metal selection — Proper hand tool selection — Adjust voltage — Set wire speed — Proper gas flow rate — Parts set up and preheated as necessary	*GMAW and FCAW,* Unit 3, Job Sheet 1—Set up or replace wire on a flux-cored wire feeder; Job Sheet 2—Set up FCAW equipment for semiautomatic flux-cored welding; Job Sheet 3—Prepare mild steel for FCAW

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Flux-Cored Arc Welder	**MAVCC Tasks**
E.04 Operate flux cored arc welding equipment — Flat single pass surfacing welds — Flat multiple pass, multi-directional, surfacing welds — Workmanship	*GMAW and FCAW*, Unit 3, Job Sheets 4 through 15
E.05 Make fillet welds, 1F, 2F, 3F, on plain carbon steel plate	*GMAW and FCAW*, Unit 3, Job Sheet 4—Weld to specifications a fillet weld lap joint on mild steel in the flat position; Job Sheet 5—Weld to specifications a fillet weld T-joint on mild steel in the flat position; Job Sheet 6—Weld to specifications a fillet weld lap joint on mild steel in the horizontal position; Job Sheet 7—Weld to specifications a fillet weld T-joint on mild steel in the horizontal position; Job Sheet 8—Weld to specifications a fillet weld lap joint on mild steel in the vertical position; Job Sheet 9—Weld to specifications a fillet weld T-joint on mild steel in the vertical position
E.06 Make groove weld, 1G, 2G, and 3G positions, on plain carbon steel plate with backing	*GMAW and FCAW*, Unit 3, Job Sheet 12—Weld to specifications a V-groove butt joint on mild steel in the flat position; Unit 3, Job Sheet 13—Weld to specifications a V-groove butt joint on mild steel in the horizontal position; Unit 3, Job Sheet 14—Weld to specifications a V-groove butt joint on mild steel in the vertical position
Duty G: Perform Manual Oxyfuel (OF) Cutting—Refer to *Oxyacetylene Welding and Cutting* for this duty.	
Duty I: Perform Air Carbon Arc Cutting (Gouging)—Refer to *Shielded Metal Arc Welding* for this duty.	
Duty J: Perform Plasma Arc Cutting and Gouging—Refer to *Gas Tungsten Arc Welding and Plasma Arc Cutting*, Unit 3, "Plasma Arc Cutting," for this duty.	

State of Oklahoma Welding Duty/Task Crosswalk

Occupation: Flux-Cored Arc Welder	**MAVCC Tasks**
Duty K: Perform Welding Inspection and Testing	
K.01 Examine cut surfaces and edges of prepared base metal parts — Appearance — Uniformity — Proper fit-up — Base metal preparation	*GMAW and FCAW*, Unit 3, Job Sheets 4 through 15 require the student to prepare plates and inspect welds.
K.02 Examine tack, intermediate layers, and completed welds — Visual check for weld discontinuity and defects to an acceptable criteria — Destructive or non-destructive examination	*GMAW and FCAW*, Job Sheets 4 through 15

Gas Metal Arc Welding and Flux-Cored Arc Welding

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 1: GMAW Orientation and Safety	
1. Terms and definitions	17. Solve problems concerning GMAW safety
2. Advantages of the GMAW process	
3. Limitations of the GMAW process	
4. Principles of GMAW	
5. GMAW applications	
6. Benefits from learning GMAW	
7. Electrical safety requirements for GMAW	
8. Guidelines for duty cycle safety	
9. Rules for handling cables and gas and coolant hoses	
10. Rules for handling hollow castings or containers	
11. Hazards associated with arc rays	
12. Types of welding hoods	
13. Guidelines for selecting a safe lens shade for GMAW	
14. Protective clothing required for GMAW	
15. Environmental safety requirements	
16. Safety guidelines for working with electrode wire	
Unit 2: GMAW Equipment, Applications, and Techniques	
1. Terms and definitions	
2. Characteristics of short-circuit transfer	
3. Characteristics of globular transfer	
4. Characteristics of spray transfer	
5. Characteristics of pulsed spray transfer	
6. Characteristics of surface tension transfer	
7. GMAW machine controls and their functions	

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 2: GMAW Equipment, Applications, and Techniques (continued)

8. GMAW electrical controls and their functions
9. Wire feeder controls and their functions
10. Roll adjustment requirements for wire feeders
11. Preventive maintenance requirements for wire feeders
12. AWS classifications for electrode wires
13. Basic short-circuit electrode wires and their characteristics
14. Rules of thumb for GMAW, STT, and GMAW-P electrode wire selection
15. Guidelines for storing spools and coils of electrode wire
16. Types of GMAW guns and their characteristics
17. Parts of a GMAW gun tip and their functions
18. Steps in assembling contact tips, gas diffusers, nozzles, and insulators
19. Maintenance requirements for GMAW guns
20. Electrode extension and its function in GMAW
21. GMAW shielding gases and their applications
22. GMAW welding techniques and their characteristics
23. Techniques for properly ending a GMAW weld
24. Techniques for position welding with GMAW
25. Conditions that require special attention with GMAW
26. Possible causes and corrective actions for undercutting
27. Possible causes and corrective actions for porosity
28. Possible causes and corrective actions for incomplete fusion

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: GMAW Equipment, Applications, and Techniques (continued)

Related Information: What the Student Should Know

29. Possible causes and corrective actions for incomplete joint penetration
30. Possible causes and corrective actions for excessive melt-through
31. Flow meters and their use in GMAW
32. Flow rates for GMAW shielding gases
33. Guidelines for troubleshooting GMAW problems

Application: What the Student Should Be Able to Do

34. Set up wire on a GMAW wire feeder
35. Set up a flow meter and regulator for a GMAW shielding gas
36. Set up GMAW equipment for short-circuit transfer on mild steel
37. Prepare mild steel for GMAW
38. Use short-circuit transfer to lay stringer beads and build a pad on mild steel in the flat position
39. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position
40. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position
41. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position
42. Perform a guided-bend test on a welded V-groove butt joint
43. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position
44. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position
45. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position
46. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position
47. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the vertical position

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: GMAW Equipment, Applications, and Techniques (continued)

48. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position
49. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position
50. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position
51. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position
52. Set up GMAW equipment for spray transfer on mild steel
53. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position
54. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position
55. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position
56. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position
57. Use spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position
58. Set up GMAW equipment for spray transfer on aluminum
59. Prepare aluminum for GMAW
60. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position
61. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position
62. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position
63. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: GMAW Equipment, Applications, and Techniques (continued)

64. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position
65. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position
66. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position
67. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position
68. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position
69. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position
70. Set up GMAW-P equipment for pulsed-spray transfer on mild steel
71. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position
72. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position
73. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position
74. Set up STT equipment for surface tension transfer on mild steel
75. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the flat position
76. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position
77. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 3: Flux-Cored Arc Welding

1. Terms and definitions
2. Advantages of FCAW
3. Limitations of FCAW
4. How students benefit from learning FCAW
5. Equipment required for semiautomatic self-shielded FCAW
6. Types of flux-cored arc welding processes
7. Types of FCAW guns and their uses
8. Classifications for FCAW electrode wires
9. Electrode extension and visible electrode extension
10. Basic types of flux-cored wire feeders
11. Guidelines for using drive rolls and guide tubes
12. Steps for starting an arc with the semiautomatic process
13. Operating variables with flux-cored electrode wires
14. Guidelines for preparing FCAW applications
15. Guidelines for semiautomatic FCAW
16. Safety requirements for FCAW
17. Guidelines for troubleshooting FCAW problems
18. Set up or replace wire on a flux-cored wire feeder
19. Set up FCAW equipment for semiautomatic flux-cored welding
20. Prepare mild steel for FCAW
21. Weld to specifications a fillet weld lap joint on mild steel in the flat position
22. Weld to specifications a fillet weld T-joint on mild steel in the flat position
23. Weld to specifications a fillet weld lap joint on mild steel in the horizontal position
24. Weld to specifications a fillet weld T-joint on mild steel in the horizontal position
25. Weld to specifications a fillet weld lap joint on mild steel in the vertical position
26. Weld to specifications a fillet weld T-joint on mild steel in the vertical position
27. Weld to specifications a fillet weld lap joint on mild steel in the overhead position
28. Weld to specifications a fillet weld T-joint on mild steel in the overhead position
29. Weld to specifications a v-groove butt joint on mild steel in the flat position
30. Weld to specifications a v-groove butt joint on mild steel in the horizontal position
31. Weld to specifications a V-groove butt joint on mild steel in the vertical position
32. Weld to specifications a V-groove butt joint on mild steel in the overhead position

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each assignment sheet and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000,* a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want,* a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, math, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Reading Skills

Reading Comprehension

- Gain factual information
- Distinguish fact, opinion, and inference
- Recognize stereotyping and bias
- Recognize propaganda
- Analyze cause and effect
- Draw conclusions
- Make generalizations
- React to written material
- Apply word analysis techniques
- Analyze and apply what has been read to specific task
- Comprehend written information for main ideas
- Determine what information is needed

Research/ Reference

- Select useful resources
- Locate resources
- Find materials in library
- Use standard references
- Use in-book reference tools
- Use audiovisual media
- Use computer database
- Use magazines and newspapers

Functional Reading

- Interpret forms and records
- Follow written instructions
- Interpret graphics and symbols
- Interpret abbreviations/acronyms
- Read aloud
- Apply/understand technical words that pertain to subject

Basic Skills

Writing Skills

Language

- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition

- Use complete sentences
- Develop preliminary outline
- Use topic sentences
- Use introductory/closing paragraphs
- Compose reports
- Compose essays
- Proofread and edit
- Construct graphics and symbols

Research

- Take notes
- Use note cards
- Create bibliography
- Use footnotes
- Outline material

Functional Writing

- Complete forms and records
- Write instructions
- Write letters
- Write job applications
- Write resumes
- Use word processing
- Use computer graphics
- Use content area vocabulary

Math Skills

Operation and Calculation

- Round off numbers
- Estimate answers
- Use scientific notations
- Use exponential notations
- Calculate with whole numbers
- Calculate with fractions
- Calculate with decimals
- Convert whole numbers to fractions
- Convert whole numbers to decimals
- Solve numerical expressions
- Solve formulae and equations
- Obtain squares and square roots
- Convert units of measure
- Perform metric calculations

Math Application

- Solve word problems
- Select/apply mathematical formula
- Select/apply mathematical procedure
- Use English and metric measures
- Solve time/rate/distance problems
- Solve ratio/proportion problems
- Solve percent problems
- Apply techniques of scaling
- Apply algebra principles
- Apply geometry principles
- Apply trigonometry principles

Data Analysis and Display

- Interpret charts and tables
- Interpret graphs
- Collect/record data
- Apply sampling techniques
- Apply principles of probability
- Construct charts and tables
- Construct graphs
- Calculate statistics
- Interpret statistics
- Interpret plans/blueprints
- Draw facility to scale

Math Skills (Continued)

Functional Math

- Make measurements
- Perform banking transactions
- Make change
- Solve practical problems
- Calculate gross earnings
- Solve income/expense problems
- Prepare a budget
- Calculate interest
- Solve interest problems
- Calculate sales tax
- Determine income tax
- Use calculator for computation
- Use computer for computation
- Use computer spreadsheets
- Apply computation skills as they are actually used on the job
- Calculate measurements taken from measuring devices
- Perform/prepare an inventory
- Calculate and compare shipping costs
- Prepare financial report

Science Skills

General Science

- Apply computing skills
- Apply scientific method of inquiry
- Conduct experiments
- Investigate science ethics
- Investigate science history
- Investigate/apply economics in technology
- Use scientific instruments
- Investigate/apply technology
- Collect specimens
- Construct model to depict basic concept of ----

Life Science

- Identify/classify living organisms
- Investigate biological history of the earth
- Investigate food chains, webs, pyramids
- Investigate/apply principles of human development
- Investigate/apply principles of genetics/heredity
- Investigate/apply principles of anatomy/physiology
- Investigate health issues
- Observe health code/sanitation requirements

Physical Science

- Analyze/classify matter
- Investigate forms/changes of matter
- Investigate forms/changes of energy
- Investigate/apply chemical properties
- Investigate/apply physical laws

Earth Science

- Investigate physical characteristics of the earth
- Investigate geological history of the earth
- Investigate physical forces acting on the earth
- Solve problems of longitude, latitude, and time zones
- Investigate conservation of physical resources
- Investigate conservation of living resources
- Investigate issues of environmental impact
- Apply science principles to environmental issues

Oral Communication Skills

Oral Presentation

- Make informative presentations
- Make persuasive presentations
- Present personal opinion/viewpoint
- Use good speaking techniques
- Select/use words effectively
- Use effective body language
- Present appropriate appearance
- Integrate audio and/or visual materials into oral presentations
- Adapt presentation to specific audience

Listening

- Apply active listening skills
- Distinguish fact, opinion, and inference
- Draw conclusions/make generalizations
- Analyze/identify point of view

Interactive Communication

- Give/follow oral directions
- Apply questioning techniques
- Conduct/receive interviews
- Analyze/apply nonverbal communication
- Work effectively in a group
- Communicate with clients/customers/patients
- Communicate with coworkers
- Communicate with supervisors
- Communicate with professional colleagues/associates
- Apply telephone etiquette

Interpersonal or Relating Skills

General Relating

- Investigate/apply communication process models
- Analyze/apply nonverbal communication
- Investigate/apply cross-cultural communication
- Interact with coworkers
- Interact with supervisors
- Interact with clients/customers/patients
- Interact with professional colleagues/associates
- Interact with family/friends
- Participate in group activities
- Participate in industrial relations/functions
- Identify personal values/attitudes
- Apply information to life experiences

Teamwork/ Cooperation

- Identify values/attitudes
- Identify needs/drives
- Select/apply appropriate behavior
- Investigate/identify personal styles
- Investigate/identify group/corporate climate
- Give/receive feedback
- Identify hidden purposes
- Investigate/apply group dynamics
- Control undesirable/inappropriate behavior
- Resolve conflicts
- Clarify goals/objectives
- Devise "win/win" situations
- Build consensus
- Generate ideas
- Present point of view

Leadership/ Influence

- Analyze/apply leadership styles
- Analyze/apply management styles
- Obtain confidence of others
- Develop esteem in self/others
- Persuade others
- Analyze/apply motivation techniques
- Provide positive coaching

Critical Thinking Skills

Cognitive Activities

- Collect/record information
- Identify critical elements/issues
- Define a problem
- Identify underlying causes
- Apply a problem-solving model
- Analyze/synthesize information
- Identify/analyze underlying assumptions
- Draw conclusions
- Predict results/outcomes
- Identify/evaluate consequences
- Identify/develop alternatives
- Evaluate alternatives
- Select an alternative
- Devise a solution
- Create a finished product
- Apply intuitive thinking techniques
- Transfer knowledge/training to new situations
- Apply new technology
- Develop an action plan
- Evaluate results/outcomes
- See relationship between two or more ideas, objects, or situations

Employability Skills

Job Search/ Selections

- Analyze personal occupational aptitudes/preferences
- Investigate employment prospects of a career field/occupation
- Investigate training requirements for a career field/occupation
- Investigate benefits of a career field/occupation
- Compare/evaluate career options
- Analyze impact of work on individual and family life

Job Acquisition/ Development

- Develop personal career path
- Locate appropriate jobs
- Analyze duties/requirements/benefits of specific job
- Master specific job task/procedure
- Complete job-related applications
- Write a letter of application
- Write personal resume
- Interview for a job
- Apply business etiquette
- Practice good work habits/attitudes
- Practice good personal presentation
- Develop self confidence/esteem
- Develop effective leadership
- Deal effectively with supervisors
- Deal effectively with coworkers
- Deal effectively with professional colleagues/associates
- Deal effectively with customers/clients/patients
- Follow established rules, regulations, and policies
- Promote the goals and values of the organization
- Exert a high level of effort and perseverance towards goal attainment
- Set high standards for self in completion of a task

Resource Management

- Complete task in timely manner
- Determine cost, time, and resources to complete a task
- Perform routine tasks related to equipment operation and/or maintenance

Job Safety

- Demonstrate safe use of tools, equipment, and supplies
- Observe safety rules
- Wear safety equipment
- Follow safety procedures
- Demonstrate proper use of safety device

Basic Skills

Social Studies Skills

Information Analysis

- Collect/record data
- Interpret graphical information
- Construct graphical information
- Interpret maps/globes
- Interpret statistical information
- Analyze/interpret demographic information
- Distinguish trends and predicts impact of actions on systems operations

Social Studies Application

- Investigate/apply U.S. history
- Investigate/apply world history
- Investigate/apply U.S. geography
- Investigate/apply world geography
- Investigate/apply principles of government/politics
- Investigate/apply principles of economics
- Investigate/apply principles of ethics
- Investigate/apply principles of sociology
- Investigate/apply cross-cultural studies

Functional Social Studies

- Practice responsible personal economics
- Prepare a personal budget
- Use credit responsibly
- Practice good work ethics
- Participate in industrial relations
- Interact with people of different races/cultures
- Investigate/participate in government
- Investigate/apply American legal practices
- Select/use sources of information on current events
- Analyze current events
- Analyze consumer issues
- Analyze social issues
- Analyze conservation/ecology issues
- Analyze social impact of science/technology
- Analyze economic impact of science/technology
- Understand how social, organizational, and technological systems work and operate effectively

Technology Skills

Selection	• Choose procedures, tools, or equipment including computers and related technologies that will produce the desired results
Application	• Demonstrate the proper procedures for setting up and operating equipment, including computers and their programming systems
Maintenance/ Troubleshooting	• Perform maintenance on equipment, including computers and other technologies • Identify and correct problems with equipment • Report damaged or broken equipment to appropriate individual

BASIC SKILLS MATRIX

	Reading	Writing	Mathematics	Science
Unit 1 GMAW Orientation and Safety	X	X		
Unit 2 GMAW Equipment, Applications, and Techniques	X			
Unit 3 Flux-Cored Arc Welding	X			

Oral Communication	Interpersonal	Critical Thinking	Employability	Social Studies	Technology
		X	X		
		X	X		X
		X	X		X

Tools, Equipment, and Materials List

- Adjustable wrench
- Aluminum
- Ball peen hammer
- Bend test machine
- "C" clamps
- Chipping hammer
- Face shields
- FCAW gun and components
- Fine-cut file
- GMAW/FCAW machine and accessories
  - Coolant solenoid
  - Fine voltage control
  - Flowmeter regulator
  - Gun and cable assembly
  - Inductance control
  - Power supply
  - Slope control
  - Voltage range selector
  - Wire feeder
- GMAW gun and components
- GMAW-P machine and accessories
- Groove weld test plate, 3/8" thickness
- Metal cleaner/deoxidizer solution
- Mild steel plate
- Nozzle spray or gel
- Oxyacetylene cutting equipment
- Personal safety clothing for each student
- Pliers and clamps
- Portable grinder/sander
- Safety glasses
- Screwdriver
- Shielding gases
  - Argon
  - CO_2
  - Helium (optional)
  - Oxygen
- Spools and/or coils of electrode wire
  - E-70T series for FCAW
  - ER-70S series for GMAW
- Stainless steel brush
- Straightedge and soapstone
- STT machine and accessories
- Well-ventilated welding areas
- Wire brush

Tools, Equipment, and Materials List

- Wire feeder controls
  - Amperage/wire speed control
  - Remote unit (optional)
  - Wire-inch switch
- Wire-cutting pliers

56

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1–3

Answers to Assignment Sheet 1–9

Written Test 1–11

Answers to Written Test 1–19

Teacher Supplement

1—A Brief History of GMAW 1–21

Transparency Master

1—Types of Welding Hoods 1–23

Student Components

Student Page

Learning Activities Sheet 1–3

Objective Sheet 1–5

Information Sheet 1–7

*Assignment Sheet

1—Solve Problems Concerning GMAW Safety 1

*The Assignment Sheet is located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet located in the student edition. Modify as appropriate to include additional activities and/or resources available in your classroom.
- Make copies of any teacher supplements that will be provided to each student.
- Make a transparency from the transparency master included in this unit. This appears in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.

Suggested Activities

Teaching Suggestions

- When teaching Unit 1, you should present information on employability skills such as effective interpersonal skills, personal characteristics desired by employers, resumé preparation, and interviewing techniques. Refer to your school's resource center for more information on these topics, or visit www.careerperfect.com.
- Use Objective 6 to impress students with the career benefits that come with skills in gas metal arc welding. Find shops or industries in your area that use the GMAW process. Have welders from those businesses talk to the class about the advantages of having GMAW skills.
- When teaching Objective 8, stress the importance of the welding machine and other electrical components in the GMAW process. Since GMAW requires articulate electrical settings and adjustments, students should learn to appreciate the "machine" as an extremely important part of the process.
- Be sure to demonstrate how to work with electrode wires when you get to Objective 16. Improperly handled wires contribute to personal injury and, sometimes, destruction of valuable supplies.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheet. Rate the student using the criteria listed on the assignment sheet. See Answers to Assignment Sheet for correct answers. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Technology, Welding Handbook*, 8th ed. Vol. 1. Miami, FL: American Welding Society, 1987.
- *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company.
- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*. 8th ed. Vol. 2. Miami, FL: American Welding Society, 1991.
- *The Procedure Handbook of Arc Welding*. 13th ed. Cleveland, OH: The Lincoln Electric Company, 1994.

Suggested Supplemental Resources

Print Media

- *Gas Metal Arc Welding*—This technical guide explains the process, equipment, applications, procedures, safety, and welding symbols in detail. For more information, contact:

  Hobart Institute of Welding Technology
  400 Trade Square East
  Troy, OH 45373
  800.332.9448
  www.welding.org

- *Welding Design & Fabrication* is a magazine that reports on processes and equipment, materials, safety, testing, and inspection in the manufacture of fabricated-metal products, structural projects and equipment maintenance. For subscription information, contact:

  Penton Media, Inc.
  1100 Superior Avenue
  Cleveland, OH 44114
  www.penton.com

Electronic Media

- Videos
  - *Health and Safety Factors in Welding* (27 minutes)—This is an excellent video to educate welders on potential health and safety concerns in this occupation. (9018A)
  - *Health Factors in Welding Operations* (28 minutes)—This video explains a variety of precautions, possible health problems involved in welding operations, and tips on how to generally improve your health. (1001H)

Suggested Activities

- *Safe Use of Compressed Gas Cylinders* (8 minutes)—Designed for anyone using compressed gas cylinders. It explains basic safety procedures, compressed gas cylinder hazards, and how to properly use these cylinders. (D60007)

- *Safe Handling of Compressed Gas Cylinders* (9 minutes)—This video explains how to handle cylinders, proper storage, and general safe handling procedures. (D70007)

The videos listed above and on the previous page are available from MAVCC at www.mavcc.org, or call 800.654.3988. Most videos are also available in CD-ROM format.

- *GMAW Basic* (V10.0)—Basic program has 24 topics. Available from:

  Hobart Institute of Welding Technology
  400 Trade Square East
  Troy, OH 45373
  800.332.9448
  www.welding.org

- *GMAW Made Simple* (GMAW-V)—This 47-minute VHS video delivers a hands-on view of GMAW in a real shop setting. Available from:

  American Welding Society
  550 N.W. LeJeune Road
  Miami, FL 33126
  800.443.9353
  www.aws.org

- *Gas Metal-Arc Welding Video* (F52.3)—This program is specifically designed to be used individually so that the viewer can learn at their own pace and receive reinforcement where and when they need it most. ISBN/ISSN: 0-8064-1365-4. Available from:

  Delmar Publishing
  3 Columbia Circle
  P.O. Box 15015
  Albany, NY 12212-5015
  800.347.7707
  www.delmar.com

- Online Resources
  - www.lincolnelectric.com—Lincoln Electric's website contains information on their products including welders, wire feeders, software, and consumables. Technical assistance and links to operations manuals are also available. For more information visit their website or contact:

    The Lincoln Electric Company
    22801 St. Clair Ave.
    Cleveland, OH 44117
    216.481.8100

  - www.millerwelds.com—Miller Electric's website includes technical articles, questions and answers, safety topics, and ordering information for various educational welding products such as posters, videos, and CD-ROMs. For more information, visit their website or contact them at:

    Miller Electric Manufacturing Co.
    1635 W. Spencer St.
    P.O. Box 1079
    Appleton, WI 54912-1079
    920.734.9821

  - www.aws.org—The American Welding Society's website contains an online catalog of all of their welding products including books, videos, and CD-ROMs. For more information, visit their website or contact them at:

    American Welding Society
    550 N.W. LeJeune Road
    Miami, FL 33126
    800.443.9353

Answers to Assignment Sheet

Assignment Sheet 1

Solve Problems Concerning GMAW Safety

Note: Students' answers should approximate those given.

1. Yes. All electrical power sources should be disconnected before working on any electrical equipment.
2. Yes. You've exceeded the safe limits of the duty cycle and should stop welding and check equipment or wait a safe time before continuing.
3. Yes. Only clean, dry rags should be used to clean cables and hoses.
4. Yes. Even though sparks may not injure you, the radiation from the arc is strong enough to burn or sometimes blister bare skin.
5. Yes. Always wear safety glasses when working with electrode wire because a loose end could spring up and injure an eye.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Automatic
2. Consumable
3. Contaminants
4. Deposition
5. Gas Metal Arc Welding (GMAW)
6. Inert
7. Metal Inert Gas (MIG)
8. NEMA
9. Oxygen displacement
10. Reactive
11. Semiautomatic
12. Shielding gases
13. Toxic hazards

_____ a. Elements in air, impurities in shielding gases, or chemical reactions between base metals and electrodes

_____ b. Inert gases such as argon or helium, or reactive gases such as CO_2, which are directed under pressure into a weld zone to protect it from atmospheric contamination

_____ c. A nonstandard term still used in reference to GMAW

_____ d. That which can be used up; a way of defining electrode wires used in GMAW

_____ e. A GMAW process in which the welding current is continuous in a programmed application; the workpiece travels under a welding head or the welding head travels along the workpiece

_____ f. The weight of filler metal placed onto or into a weld in a given period of time

_____ g. An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding comes entirely from an externally supplied gas

_____ h. An element that has no active properties

_____ i. National Electrical Manufacturer's Association

_____ j. A reduction of oxygen in the breathing zone around a welding activity caused by any arc or flame

Written Test

_____ k. Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

_____ l. An element or gas that has properties which will actively combine with other elements present in a base metal or a filler electrode at high temperature

_____ m. A GMAW process in which the welding current is completed as an operator squeezes a gun trigger

Objective 2

Complete statements concerning the advantages of the GMAW process by circling the correct answers.

a. **(Those with basic welding skills) (Beginners)** can be more quickly trained to weld with the GMAW process than with any other welding process.

b. Because GMAW better controls **(deposition) (heat)** in the weld zone, it reduces distortion in base metals.

c. Because the GMAW arc is **(usually) (always)** visible to the operator, better welds are possible.

d. GMAW gives a high deposition efficiency with up to **(98%) (90%)** of the welding wire deposited in the joint.

e. GMAW is adaptable to **(both ferrous and nonferrous metals) (only ferrous metals)** in all thicknesses through modification of electrode wire and shielding gas selections.

f. GMAW is adaptable to **(only semiautomatic) (either automatic or semiautomatic)** operation.

g. GMAW reduces welding costs because it usually requires **(moderate) (no)** cleanup.

Objective 3

Select true statements concerning limitations of the GMAW process by placing an "X" in the blanks next to the true statement(s).

_____ a. GMAW will function in a windy environment, but it requires modification.

_____ b. GMAW requires careful setting of electrical components.

Objective 4

Complete statements concerning principles of GMAW by circling the correct answers.

a. The GMAW process usually operates on **(DCEP) (DCEN)**.

b. The GMAW process is controlled by arc amperage and **(voltage) (wire speed)**.

c. Arc amperage in the weld zone is controlled by feeding a bare electrode wire through a wire feeder and cable assembly at a preset feed speed which is calibrated in **(inches-per-minute) (feet-per-minute)**.

d. Voltage is controlled by **(wire feed speed) (a dial on the welding machine)**.

e. As the arc is struck, a shielding gas is forced around the electrode wire and the weld zone to stabilize the arc and protect the molten filler metal and base metal from **(contaminants) (wind)**.

Objective 5

Solve problems concerning GMAW applications by circling the number of the item that best solves each of the following problems.

a. A project calls for aluminum components. You have to decide if the GMAW process is suitable for the job. You should answer:

(1) Definitely not.
(2) Yes, but it should require extensive modifications.
(3) Yes, GMAW is especially suitable for welding aluminum.

b. A friend in an auto repair shop is thinking about buying a welding rig. Your friend wants to know your recommendation. You should answer:

(1) Nothing beats good old stick welding.
(2) GMAW is especially effective where fit-up is not critical, and for an automotive shop, it would be good.
(3) Try to work with an oxyacetylene rig because they are cheaper and can do almost everything other rigs can do.

c. A project calls for several different thicknesses of metal. You have to decide if GMAW is suitable for the job. You should answer:

(1) Definitely because quick electrical adjustments can be made to adjust the wire to the metal thickness without having to change the wire.
(2) Definitely because the wire selection can be tailor-made for every metal thickness, and changing wire is a snap.
(3) This is definitely a job for the SMAW process where electrode sizes can be changed quickly.

Objective 6

Select true statements concerning benefits from learning GMAW by placing an "X" next to the true statements.

_____ a. Working with GMAW is a good way for a student to learn the concept of a consumable electrode, and shielding gases and their uses.

_____ b. The GMAW process introduces students to electrical concepts and electrical controls that other welding processes do not require.

_____ c. GMAW gives students a better idea of what "operator control" really means in a welding process.

_____ d. As students work with GMAW, they will experience better visibility of the arc, electrode, and total weld zone than with other processes.

_____ e. Learning GMAW provides no additional job-getting skills for industry.

Objective 7

Select true statements concerning electrical safety requirements for GMAW by placing an "X" next to the true statements.

_____ a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.

_____ b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

_____ c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

_____ d. Dip a gun in water to cool it only in emergencies.

_____ e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the gun because open-circuit voltages from two machines are increased and can cause a severe shock.

_____ f. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

_____ g. Keep welding cables as close to the work area as possible and do not connect cables to building framework because current can be directed through lifting chains and cables and weaken them.

_____ h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

Objective 8

Select true statements concerning guidelines for duty cycle safety by placing an "X" next to the true statements.

Note: For a statement to be true, all parts of the statements must be true.

_____ a. Duty cycle is the percent of time during an arbitrary test period that a power source can be operated without overheating.

_____ b. Duty cycle is based on a one-hour period and the length of time during that period that a machine can be safely operated.

______ c. Since duty cycle is rated at the maximum output of a welding machine, the lower the percentage, the more attention is required to time spent actually welding.

______ d. Use the NEMA classification on the welding machine as a guideline to safe operation:

- Class I—Rated to deliver output at duty cycles of 60, 80, or 100%
- Class II—Rated to deliver output at duty cycles of 30, 40, or 50%
- Class III—Rated to deliver output at duty cycles of 20%

Objective 9

Solve problems concerning rules for handling cables and gas and coolant hoses by circling the number of the item that best solves each of the following problems.

a. You notice another worker dragging a cable through dirt and trying to pull it over a tool rack. The solution to the problem should be:

(1) Carry the cable through the dirt and place it safely over the tool rack because cables should not be dragged through oil or dirt, and should not be pulled over obstructions.
(2) Be sensible and move the welding machine to avoid having to manipulate the cable.
(3) Make sure the dirt is dry and that the cable is moving freely over the obstruction.

b. You notice another worker cleaning a cable with a rag that has been wet with gasoline. The solution to the problem should be:

(1) Be sure to clean the gasoline off with a dry rag after the cable is cleaned.
(2) Be sure the rag is only slightly wet with gasoline.
(3) Use a safe cleaning solvent because oily rags or gasoline-soaked rags should never be used to clean cables.

c. You notice a fellow worker has a welding cable draped over a gas cylinder. The solution to the problem should be:

(1) Make sure the welding current is off.
(2) Move the cable to a safe position because a welding cable should never be draped over a gas cylinder.
(3) Disconnect the cable completely so there will be no risk involved.

Objective 10

Complete statements concerning rules for handling hollow castings or containers by circling the correct answers.

a. Hollow castings or containers should be **(thoroughly washed) (vented)** before any heating, cutting, or welding activity.

b. Tanks, drums, and sealed containers should not be heated, cut, or welded until they have been carefully **(aired out) (purged)** of any toxic or flammable materials.

Written Test

Objective 11

Select true statements concerning hazards associated with arc rays by placing an "X" next to the true statements.

_____ a. *A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.*

_____ b. Radiation from a welding arc is strong enough to burn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

_____ c. Workstations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

Objective 12

Complete statements concerning types of welding hoods and their characteristics by circling the correct answers.

a. Stationary filter lens—This type hood has a **(fixed) (flexible)** lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires.

b. Flip-front filter lens—This type hood has a lens housing with a front side that can be flipped up so that it leaves a **(dark) (clear-glass or plastic)** lens that permits the hood to be worn while chipping.

c. Auto darkening lens—This type of lens contains sensors that automatically change the shade lens from **(clear to dark) (dark to clear)** in a fraction of a second when you start to weld.

Objective 13

Complete statements concerning guidelines for selecting a safe lens shade for GMAW by circling the correct answers.

a. Safe lens selection for GMAW depends on electrode size, which in turn dictates **(duty cycle) (amperage or current)** setting.

b. The rule of thumb for GMAW lens selection is that the higher the amperage, the **(higher) (lower)** the lens shade number required.

c. Operator comfort is also an important part of lens shade selection, and some welders can operate safely with a minimum protective shade while others may require a **(lighter) (darker)** shade for comfort and safety.

d. In all cases, never use the GMAW process with anything less than a **(#9) (#7)** lens shade.

e. When you remove your welding hood and see white spots or blotches as after images, switch to a shade at least **(one number darker) (one number lighter)**, or check the seal on your lens.

Written Test

Objective 14

Select true statements concerning protective clothing required for GMAW by placing an "X" next to the true statements.

_____ a. Shirts—Should be lightweight and have short sleeves so the welder will remain cool

_____ b. Pants—Should not have cuffs and should be long enough to come down over shoe/boot tops

_____ c. Welding caps—Should be worn to protect hair from sparks and spatter and should have a flexible bill that can be slipped around to cover either ear and keep sparks or metal spatter out of the ear opening

_____ d. Boots—Should be made of canvas with uppers that reach above the ankle to help prevent burns from sparks and spatter

_____ e. Gloves—Should be made of heavy leather and should contain gauntlets which are required for all welding and cutting activities

_____ f. Jackets and aprons—Jackets and aprons made of leather should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard.

_____ g. Safety glasses—Should have metal frames and only need to be worn when grinding

_____ h. Face shield—Should wear a clear-plastic type of face shield to provide good visibility when grinding or sanding base metals for GMAW

Objective 15

Complete statements concerning environmental safety requirements by writing the correct answers in the blanks.

a. Ventilation—Many welding activities produce ____________________ fumes and vapors that are hazardous to breathe, and every workstation should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

b. Respirators—In confined areas where the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter-type mask that cannot compensate for ____________________ ____________________.

c. Noise—This is a workplace hazard frequently overlooked, but earplugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are ______________________________.

d. Lighting—Lighting in a work area or at a workstation should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to ________ __________, irritation, and poor work.

Objective 16

Select true statements concerning safety guidelines for working with electrode wire by placing an "X" next to the true statements.

_____ a. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye.

_____ b. Make sure you have the correct spool or coil before loading and cutting tie wires.

_____ c. Hold the free end of electrode wire firmly to avoid backlash during the reloading procedure because failure to do so could ruin an entire spool or coil.

_____ d. Position coils close to the reel before lifting, and lift with your legs, not your back, because standard coils weigh 60–100 pounds.

_____ e. Never look into a gun while you are feeding wire through it, and never point the gun at anyone else.

_____ f. Check feeding by placing your finger or hand over the contact tip.

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1	a. 3 b. 12 c. 7 d. 2 e. 1 f. 4 g. 5 h. 6 i. 8 j. 9 k. 13 l. 10 m. 11
Objective 2	a. Beginners b. Heat c. Always d. 98% e. Both ferrous and nonferrous metals f. Either automatic or semiautomatic g. No
Objective 3	b
Objective 4	a. DCEP b. Voltage c. Inches-per-minute d. A dial on the welding machine e. Contaminants
Objective 5	a. 3 b. 2 c. 1
Objective 6	a, b, c, d
Objective 7	a, b, c, e, f, g, h
Objective 8	a, c, d
Objective 9	a. 1 b. 3 c. 2
Objective 10	a. Vented b. Purged
Objective 11	a, b, c

Answers to Written Test

Objective 12	a. Fixed b. Clear-glass or plastic c. Clear to dark
Objective 13	a. Amperage or current b. Higher c. Darker d. #7 e. One number darker
Objective 14	b, c, e, f, h
Objective 15	a. Toxic b. Oxygen displacement c. Continuous d. Eye fatigue
Objective 16	a, b, c, e

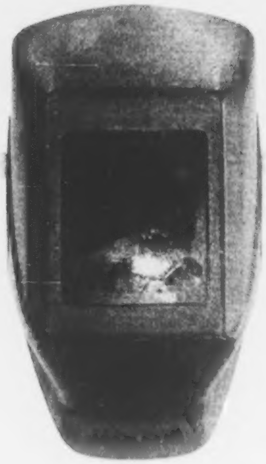
Teacher Supplement 1—A Brief History of GMAW

The fundamental idea of GMAW was introduced in the 1920s. However it wasn't until 1948 that it became commercially available. In the beginning GMAW was mainly used to weld aluminum. Today, GMAW is used in automotive shops and other industries where critical welding applications are needed.

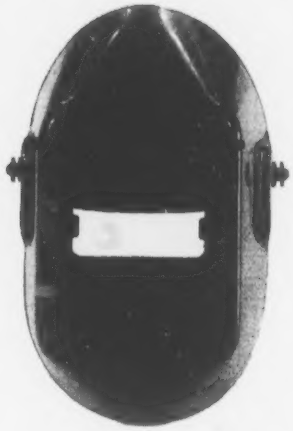
1. After World War II, aluminum and magnesium were used more and more in industry because of their strength-to-weight ratios and their better resistance to corrosion, but thicknesses above 1/4″ were difficult to weld with the TIG process because of problems with heat transfer.
2. The need for a welding process that could control heat in a small area led to the first patent for welding with consumable electrode welding equipment. This was issued in 1948.
3. Hand in hand with the development of the GMAW process came the development of an iron powder covering for electrodes which provided a greater deposition rate and faster welding speeds.
4. Other developments led to the use of gas mixtures to provide a more stable welding arc instead of using pure argon or helium as a shielding gas.
5. As the use of the GMAW process expanded, the high cost of argon and helium led to the use of CO_2 (carbon dioxide) as a shielding gas, an idea that had been patented by John C. Lincoln back in 1918.
6. The use of low-cost CO_2 as a shielding gas led to the expansion of the GMAW process into automotive shops and other industries where less critical welding applications are demanded.

   Note: Although "MIG" is frequently used to mean the same thing as GMAW, it is not appropriate in some cases because the "I" in MIG means that an inert gas is used, but since CO_2 is a reactive gas, the use of MIG to define the process is not technically correct. The term "MIG" has been replaced by GMAW.

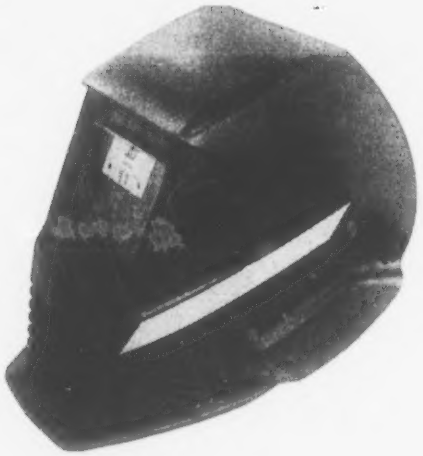
Types of Welding Hoods



Stationary filter lens



Flip-front filter lens



Auto darkening lens

Unit 2 GMAW Equipment, Applications, and Techniques

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 2–5

Written Test 2–11

Answers to Written Test 2–29

Transparency Masters

- 1—GMAW Contact Tip Position 2–33
- 2—GMAW Travel Angle 2–35
- 3—GMAW Bead Formation 2–37
- 4—GMAW Bead Termination 2–39
- 5—Major Advantages of STT 2–41
- 6—Flow Meter 2–43

Student Components

Student Page

Learning Activities Sheet 2–3

Objective Sheet 2–11

Information Sheet 2–17

Student Supplements

- 1—Recommended Electrodes for GMAW 2–43
- 2—Surface Tension Transfer Process 2–45
- 3—Inverter Technology 2–47
- 4—Recommended Initial Settings for STT 2–49
- 5—Recommended GMAW Shielding Gases 2–53
- 6—Gas Metal Arc Welding Conditions 2–57
- 7—GMAW/Microprocessor Troubleshooting 2–59

*Job Sheets

- 1—Set Up Wire on a GMAW Wire Feeder 3
- 2—Set Up a Flow Meter and Regulator for a GMAW Shielding Gas 7
- 3—Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel 9
- 4—Prepare Mild Steel for GMAW 11
- 5—Use Short-Circuit Transfer to Lay Stringer Beads and Build a Pad on Mild Steel in the Flat Position 13
- 6—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 17

Unit Contents

7—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 21
8—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 25
9—Perform a Guided-Bend Test on a Welded V-Groove Butt Joint 29
10—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 35
11—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 39
12—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 43
13—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position 47
14—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position 51
15—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position 55
16—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position 61
17—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position 65
18—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position . 69
19—Set Up GMAW Equipment for Spray Transfer on Mild Steel ... 75
20—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 79
21—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 83
22—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 87
23—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 91
24—Use Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 95
25—Set Up GMAW Equipment for Spray Transfer on Aluminum ... 99
26—Prepare Aluminum for GMAW 103
27—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position 105
28—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position 109
29—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position 113
30—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position 117
31—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Up Position 121
32—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position 125

33—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position 129
34—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position 133
35—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position 137
36—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position 141
37—Set Up GMAW-P Equipment for Pulsed-Spray Transfer on Mild Steel 145
38—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 147
39—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 151
40—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position ... 155
41—Set Up STT Equipment for Surface Tension Transfer on Mild Steel 159
42—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 161
43—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 165
44—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position ... 169

*Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet located in student edition. Modify as appropriate to include additional activities and/or resources available in your classroom.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Suggested Activities

Teaching Suggestions

- Discuss area shops or manufacturers who use gas metal arc welding in their production. Invite owners or supervisors to talk to the class about job opportunities for welders with GMAW skills.
- Use the early objectives to impress upon students the importance of electrical controls in GMAW. Stress relationships between control settings and electrode extension. Note that electrode extension is the new AWS reference for what was called electrode stickout.
- When discussing Objective 6 (STT), refer to Student Supplements 2, 3, and 4. Explain to students that STT uses inverter technology (hardware) and waveform technology (software).
- In Objectives 22 and 23, stress the importance of welding technique. Inform students that part of their job sheet evaluations will rate welding technique as well as crater and fill technique for properly ending a GMAW weld.
- Reinforce Objective 33 by staging problems for students to troubleshoot.
- There are many job sheets in this unit, and they have been arranged so that all mild steel job sheets and all aluminum job sheets are grouped together. Group the job sheets to best take advantage of resources in your welding facility. Try to localize instruction so that all students will get training on both mild steel and aluminum projects.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Althouse, Andrew D., Carl H. Turnquist, and William A. Bowditch. *Modern Welding*. South Holland, IL: The Goodheart-Willcox Co., Inc., 2000.
- Connor, Leonard P., ed. *Welding Technology, Welding Handbook*. 8th ed. Vol. 1. Miami, FL: American Welding Society, 1987.
- *Lincoln Aluminum MIG Welding Guide*. Cleveland, OH: The Lincoln Electric Company, 1999.
- *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company.
- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*. 8th ed. Vol. 2. Miami, FL: American Welding Society, 1991.
- *The Procedure Handbook of Arc Welding*. 13th ed. Cleveland, OH: The Lincoln Electric Company.

Suggested Activities

Suggested Supplemental Resources

Electronic Media

- Videos
  - *Gas Metal Arc Welding* (54 minutes)—This video focuses on the step-by-step safety procedures involved in setup and operation of GMAW. Proper clothing, safety, and equipment related to GMAW are discussed and 12 welds are performed in both flat and vertical position. (C12007)

    To order, contact MAVCC at www.mavcc.org, or call 800.654.3988.
  - *Short Ckt. Metal Transfer*—This program examines how a wire and shielding gas accomplish the same work as a stick electrode. Basic MIG welding equipment is examined and some basic how-to information about common joints is discussed.
  - *GMAW Set-up Procedures*—This video demonstrates procedures common in setting up a MIG welding system including shielding gas, flowmeter, and threading wire. (12 min)
  - *GMAW Transfer*—The short circuit, globular, spray and pulsed spray transfers are demonstrated in real time and super slow motion. Correct parameters and shielding gas types for each transfer are also discussed. (8 min)

    The three videos listed above are available from:

    Miller Electric Manufacturing Co.
    1635 W. Spencer St.
    P.O. Box 1079
    Appleton, WI 54912-1079
    920.734.9821
    www.millerwelds.com
  - *GMAW Advanced* (V11.0)—Advanced program has 14 topics. Available from:

    Hobart Institute of Welding Technology
    400 Trade Square East
    Troy, OH 45373
    800.332.9448
    www.welding.org

- Tape 4: *Gas Metal, Flux Cored-Arc Welding (MIG)*—This 24-minute video is part of a four-tape series called *Arc Welding Explained*. Program activity sheets are available for the viewer to fill out during "stop slates" in the video program. A CD-ROM is also available that includes the series videos, pre and post test questions, and video glossary. ISBN 0-8064-1366-2 (for the video)

  Available from:

  Delmar Publishing
  3 Columbia Circle
  P.O. Box 15015
  Albany, NY 12212-5015
  800.347.7707
  www.delmar.com

- *Metal Transfer in the Gas Shielded Arc Welding of Steel* (SICA-5)—VHS videocassette, $50 postage paid

  Six-minute slow motion documentation film showing close up views of metal transfer through the welding arc. Includes views of below transition current including drop transfer and above transition current including spray transfer, dip transfer, and pulsed arc transfer.

  Sica Productions
  23 Walnut Avenue
  Clark, NJ 07066
  Tel: 732.382.0618
  Fax: 732.827.0993
  www.sicaproductions.com
  email: davesica@juno.com

- *MIG Welding, Part I* (NIM-CC-2-V92)—Covers spray transfer, globular transfer, and pulse transfer; discusses equipment and consumables
- *MIG Welding, Part II* (NIM-CC-3-V92)—Covers voltage and arc length, current and wire feed speed; explains making a weld in detail; details welding and readjusting the settings; discusses troubleshooting procedures
- *MIG Welding, Part III* (NIM-CC-4-V92)—Discusses advantages of MIG in industry; covers the importance of correct current and voltage settings and programmable units; explains programmable wire feeders; emphasizes fitting correct contact tips and hose liners, and setting up wire feeder
- *MIG Welding, Part IV* (NIM-CC-5-V92)—Covers stickout, spatter, and electrode wires; discuss on-gun fume extractors and trigger latching

The videos listed above are available individually or as a set (NIM-CC-MIG-V92). For ordering information, contact:

NIMCO
102 Hwy. 81 North
P.O. Box 9
Calhoun, KY 42327-0009
800.962.6662
www.nimcoinc.com

- CD-ROM
  - *Gas Metal Arc Welding*—This CD consists of six segments that cover the following: introduction to GMAW; GMAW safety issues; equipment orientation; fundamental welding; butt, lap, and T-joints; vertical exercises; and overhead exercises. CDs are available in Spanish and English. Available from:

Storck Interactive Training, Inc.
P.O. Box 349
4345 Highway 33 W
West Bend, WI 53095
Tel: 262-335-9796

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Electrode extension
2. Globular transfer
3. Inductance
4. Inverter technology
5. Metal core
6. Microprocessor
7. Out-of-position welding
8. Pulsed spray transfer
9. Short-circuit transfer
10. Slope
11. Slope control
12. Spray transfer
13. Surface tension transfer
14. Travel angle
15. Travel speed
16. Work angle

_____ a. The slant of the volts versus amp curve, or the volts change per 100 amps

_____ b. The rate of rise of current as opposed to the final amount of current available; used in short-circuit transfer to increase or decrease the number of short-circuit metal transfers per second

_____ c. The angle between the electrode axis and the adjacent work surface

_____ d. The distance between the end of the contact tube and the end of the electrode

_____ e. The relationship of the electrode axis with respect to the direction of travel

_____ f. A GMAW application in which average currents slightly higher than those used with short-circuit transfer are used to form a droplet that goes onto a base metal as a result of short-circuiting or gravity

_____ g. A power supply control that regulates the amount of pinch force available on welding wire and controls spatter in short-circuit transfer

_____ h. A variation of spray transfer where the power source quickly pulses between a peak and background current for a fixed period of time

_____ i. The linear rate at which the arc is moved along the weld joint

_____ j. A GMAW application in which low currents, low voltages, and small diameter wires are used to weld in all positions on thin to heavy metals

_____ k. A GMAW application in which high currents, high voltages, and larger diameter wires are used to weld thicker metals mostly in the flat and horizontal positions

_____ l. A current controlled short circuiting transfer process; welding current is based on the instantaneous requirements of the arc; wire feed speed and current are independent of one another

_____ m. A GMAW process similar to FCAW except that a metal powder is inside the wire instead of flux

_____ n. Technology that uses high speed microprocessors capable of switching from peak to background current at over 40 Khz

_____ o. Any welding position other than flat

_____ p. A computer processor contained on an integrated circuit chip that has memory and associated circuits

Objective 2

Complete statements concerning the characteristics of short-circuit transfer by circling the correct answers.

a. Short-circuit transfer with GMAW is accomplished with the use of **(indirect) (direct)** current and electrode positive (DCEP).

b. Short-circuit transfer with GMAW is accomplished with a **(high) (low)** range of welding currents and **(small) (large)** diameter wires.

c. The small, fast-freezing weld pool created with short-circuit transfer makes it suited for joining **(thin) (thick)** sections, for out-of-position welding, and for bridging large root openings.

d. In short-circuit transfer, **(metal) (no metal)** is transferred across the arc gap, and the open circuit voltage of the power source must be so low that the drop of molten metal at the wire tip cannot transfer until it touches the base metal.

e. CO_2 is used as a shielding gas with short-circuit transfer because it promotes deep penetration, but mixtures of CO_2 and **(argon) (helium)** are used to control spatter.

Objective 3

Complete statements concerning the characteristics of globular transfer by circling the correct answers.

a. Globular transfer with GMAW is characterized by a very erratic globular pattern with a droplet size **(smaller) (greater)** than that of the electrode.

b. Globular transfer is accomplished with average currents **(only slightly) (much)** higher than those used with short-circuit transfer.

c. One type of globular transfer occurs when the molten drop grows until it detaches by **(spray transfer) (short-circuiting)**.

d. Another type of globular transfer occurs when **(gravity alone) (arc force)** causes the molten drop to fall onto the weld pool.

e. CO_2 is commonly used for globular transfer, especially with **(aluminum) (mild steels)**.

Objective 4

Complete statements concerning the characteristics of spray transfer by circling the correct answers.

a. Spray transfer with GMAW is accomplished with the use of **(indirect) (direct)** current and a **(positive) (negative)** electrode.

b. Spray transfer must have an argon-rich shielding gas mixture containing at least **(80%) (90%)** argon.

c. The metal transfer across the arc changes from globular to spray as current **(decreases below) (increases above)** a certain value known as the transition current.

d. Because the individual drops are equal to or **(larger) (smaller)** than the diameter of the electrode, and are nearly constantly sprayed through the arc plasma, spatter is virtually eliminated.

e. The arc is very smooth and stable, penetration is deeper than SMAW but **(more) (less)** than globular transfer mode of GMAW.

Objective 5

Complete statements concerning the characteristics of pulsed spray transfer by circling the correct answers.

a. Pulsed spray transfer is characterized by molten drops formed by the **(high) (low)** current arc, pinched off and propelled to the weld pool by the **(high) (low)** current pulse.

b. Lower average current of the pulsing mode allows all position welding and welding of **(thin) (thick)** materials.

c. Reduction of cold lapping is due to the use of a **(higher) (lower)** energy level than normally seen with short-circuit.

Objective 6

Complete statements concerning the characteristics of surface tension transfer by circling the correct answers.

a. Surface tension transfer is characterized by wire feed speed and current being totally **(reliant on) (independent of)** each other.

b. The welding current is based on the **(instantaneous) (delayed)** requirements of the arc.

c. The current is always controlled in a **(logical) (random)** manner based on what portion of the shorting cycle is to be performed.

Written Test

Objective 7

Match GMAW machine controls with their functions.

1. Coolant solenoid
2. Flowmeter regulator
3. Gun
4. Gun and cable assembly
5. Inverter power supply
6. Power supply
7. Wire feeder

_____ a. Trigger-operated on-off device through which wire, shielding gas, and coolant are controlled at the weld zone

_____ b. A rectifier-type DC welding machine which controls voltage used in the basic GMAW processes

_____ c. Utilizes solid-state components to change the incoming 60 Hz power to a higher frequency, 18 to 100 kHz

_____ d. A roller device used to vary and control the speed at which wire is fed to the welding arc in relation to amperage and wire feed speed

_____ e. An on-off switch or valve that activates coolant flow in water-cooled GMAW systems

_____ f. Cable transports power to trigger-operated gun through which the wire, shielding gas, and coolant pass

_____ g. Used to reduce high-pressure cylinder gas to low pressure gas so its flow rate can be controlled to the welding gun as measured in CFH

Objective 8

Match GMAW electrical controls with their functions. Functions continue on the next page.

1. Contactor
2. Fine voltage control
3. Inductance
4. On-off switch
5. Polarity switch
6. Power supply ammeter
7. Power supply voltmeter
8. Slope
9. Voltage range selector

_____ a. Used to complete circuit through wire feed and function as an on-off device for wire feed

_____ b. Used to calibrate and check amperage adjustments

_____ c. Used to change polarity from DCEP to DCEN so meters for amps and volts can be properly read

_____ d. Used to start or stop the electrical power to a machine

_____ e. Used to calibrate and check voltage adjustments

_____ f. Used to control wide-range voltage selection such as 12–28 volts for low range and 20–35 volts for high range

_____ g. Used to add or decrease the rate of resistance change in a welding machine for pinch control which minimizes spatter

_____ h. Used to control arc-on time in short-circuit welding to control puddle fluidity and produce a flatter, smoother weld bead

_____ i. Used to fine tune the voltage selection within the wide-range setting

Objective 9

Match wire feeder controls with their functions.

1. Cold wire inch forward
2. Cold wire inch reverse
3. Contactor dropout
4. Gas purge
5. On-off switch
6. Pulse control
7. Remote unit
8. Spot weld function
9. Voltage control
10. Wire feed control
11. Wire-inch switch

_____ a. Functions as a dual control to regulate wire feed rate in inches-per-minute in relation to amperage

_____ b. Increases or decreases burn back on electrode extension

_____ c. Controls power input into wire feed mechanism

_____ d. Makes voltage adjustment possible in situations where welding activity is far enough away from the welding machine to make it impractical to stop welding in order to make adjustments at the machine

_____ e. Routes current through a timer which provides a specific time for each trigger activation regardless of how long or briefly the trigger is held

_____ f. Permits excess wire spooled off during loading to be rewound and used, as opposed to wasted

_____ g. Used to advance wire for setting up purposes and does not activate other components

_____ h. Permits purging of a shielding gas through the gun without having wire feed at the same time

_____ i. Controls arc voltage

_____ j. Permits fast loading of wire into gun

_____ k. Wire feeders with pulse capability that may have one or more switches allowing the unit to be adjusted manually on older machines or electronically on new machines

Written Test

Objective 10

Solve problems concerning roll adjustment requirements for wire feeders by circling the number of the material that best solves each of the following problems.

a. At a GMAW operation, you notice that the electrode wire looks like it has been shaved. The solution to the problem would probably be:

(1) Replace the wire roll; it's probably bad.
(2) Loosen the tension on the wire feed roll.
(3) Let the wire feed for awhile; it will correct its own problem.

b. At a GMAW operation, you notice small flakes of wire around the feed rolls, but the wire seems to be feeding okay. The solution to the problem would probably be:

(1) There is no problem because the wire is feeding okay.
(2) Loosen the tension on the wire feed roll and clean up the metal flakes because they could pose an electrical hazard.
(3) Loosen the tension on the wire feed roll and check the size of the wire feed rollers.

Objective 11

Select true statements concerning preventive maintenance requirements for wire feeders by placing an "X" next to the true statements.

_____ a. Feed rolls should be checked and cleaned weekly.

_____ b. All electrical connections into and out of the feeder should be checked daily and tightened as required.

_____ c. The drag brake needs to be checked weekly.

_____ d. All gas hoses and connections should be inspected for leaks before each operation.

Objective 12

Select true statements concerning AWS classifications for electrode wires by placing an "X" next to the true statements.

_____ a. AWS classifications for electrode wire use letter and number designations to identify type of electrode and basic composition.

_____ b. As in other classifications, the letter E indicates electrode, and when followed by the letter R, it indicates that the filler metal may be used only as an electrode.

_____ c. Interior numbers indicate minimum tensile strength in multiples of 1,000 psi.

_____ d. The letter S indicates an electrode with shielding coating.

_____ e. Final letter-number classifications indicate special chemical compositions of the electrode wire.

Objective 13

Match basic short-circuit electrode wires with their characteristics.

1. ER70S-2	5. ER70S-6
2. ER70S-3	6. ER70S-7
3. ER70S-4	7. ER70S-G
4. ER70S-5	8. ER80S-B2

_____ a. Filler metals of this classification are used to weld 1/2 Cr–1/2 Mo, 1Cr–1/2 Mo and 1 1/4Cr–1/2Mo steels for elevated temperatures and corrosive service.

_____ b. This classification covers filler metals, which contain aluminum in addition to manganese, and silicon as deoxidizers.

_____ c. These filler metals contain slightly higher manganese and silicon contents than those of the ER70S-3 classifications, and produce a weld deposit of higher tensile strength.

_____ d. These filler metals have substantially greater manganese content than those of the ER70S-3 classifications. This provides slightly better wetting and weld appearance with slightly higher tensile and yield strengths. These filler metals are generally recommended for use with argon-oxygen shielding gas mixtures, but they are usable with argon-CO_2 and CO_2 under the same general conditions as ER70S-3.

_____ e. This classification produces less fluid weld metal which makes it ideal for welding out-of-position and for welding small diameter pipe. This wire is triple deoxidized with aluminum, titanium, and zirconium.

_____ f. Filler metals of this classification have the highest combination of manganese and silicon, permitting high current welding with CO_2 gas shielding even in rimmed steels. This filler metal is also usable out of position with short circuiting transfer.

_____ g. These filler metals are used primarily on single-pass welds, but can be used on multiple-pass welds, especially when welding killed or semi-killed steel. These filler metals will meet the requirements of this specification with either CO_2 or argon-oxygen as a shielding gas.

_____ h. This classification includes those filler metals which are not included in the preceding classes. The filler metal supplier should be consulted for the characteristics and intended use.

Written Test

Objective 14

Solve problems concerning rules of thumb for GMAW, STT, and GMAW-P electrode wire selection by circling the number of the answer that best solves each of the following problems.

a. You have been asked to set up a GMAW project for short-circuit transfer. In the supply room you find a wire spool with .025″ wire and another spool with .060″ wire. Which wire size should be selected?

(1) Neither one. A .045" wire should be used for short-circuit transfer.
(2) Either one. The electrode extension can easily be adjusted for wire size.
(3) The .025″ wire falls within the guidelines of .020″ to .045″ for short-circuit transfer.

b. You have been asked to set up a GMAW project for spray transfer. In the supply room you find a wire spool with .025″ wire and another spool with .060″ wire. Which wire size should be selected?

(1) Neither one. A .045" wire should be used for spray transfer.
(2) The .060″ wire falls within the guidelines of .045″ to .125″ for spray transfer.
(3) Either one. The electrode extension is especially easy to adjust for spray transfer.

c. You have been asked to select a wire size for a project that requires a high deposition rate at the lowest cost in materials for a spray transfer project. In the supply room you find a wire spool with .045″ wire, .060″ wire, and .125″ wire. Which wire size should be selected?

(1) Use the .125″ wire unless the project specifies a smaller wire.
(2) Use the .060″ wire and adjust electrode extension for high deposition welding.
(3) Use the .045″ wire because the smaller diameter will permit better penetration and higher deposition.

d. You have been asked to set up for STT. In the supply room you find .125, .045, and .025 wire sizes. Which size would most likely to be run with STT?

(1) .125
(2) .025
(3) .045

e. You have been asked to weld on some steel using GMAW-P. Which of the following wire sizes would you most likely use for GMAW-P?

(1) .035
(2) .020
(3) .125

Objective 15

Select true statements concerning guidelines for storing spools and coils of electrode wire by writing an "X" next to the true statements.

_____ a. Do not unseal or open spools or coils of electrode wire until they are needed for immediate use.

_____ b. Store electrode wires in a cool place.

_____ c. Use spools or coils as soon as possible after opening, and cover or reseal remaining wire prior to storage.

Objective 16

Complete statements concerning types of GMAW guns and their characteristics by circling the correct answers.

a. Air cooled—Used in **(short-circuit) (spray)** transfer when the welding application requires short distance welds or weld times that are short or intermittent

b. Water cooled—In addition to keeping the contact tip cool, the outgoing end of the gun tube is specially designed for **(maximum) (minimum)** heat transfer between the cooling water and the gas nozzle.

c. Push—A gun that has wire pushed directly into it through drive rollers in the **(gun housing) (wire feed unit)**

d. Push-Pull—A gun that houses a small electric motor that pulls the wire from a **(wire feeder) (reel)** and feeds it through the contact tips to the weld zone

e. Spool gun—A gun capable of holding a small spool of wire and feeding it through the contact points, and is used primarily in welding **(mild steel) (aluminum)** with wire that is too soft to be pushed or pulled a long distance

Objective 17

Match parts of a GMAW gun tip with their functions.

1. Contact tip
2. Gas diffuser
3. Nozzle
4. Nozzle insulator

_____ a. A copper device that spreads shielding gas out so that it flows evenly over the electrode wire and the weld zone

_____ b. Directs and holds shielding gas around the weld zone, and may be standard, tapered for tight places, or heavy duty for continuous welding

_____ c. A copper device used to guide the wire to the weld, and should be selected according to wire size and type of service, standard, heavy duty, or tapered

_____ d. Nozzle insulator—Insulates the nozzle from the welding current and holds the nozzle in place

Written Test

Objective 18

Complete statements concerning steps in assembling contact tips, gas diffusers, nozzles, and insulators by circling the correct answers.

a. Screw the gas diffuser into the end of the conductor tube assembly with **(pliers) (an adjustable wrench)**, and then tighten the Allen screw that holds the wire-feed conduit.

b. Screw the contact tip into the gas diffuser and snug it tight with **(pliers) (an adjustable wrench)**, but be careful not to damage the contact tip.

c. Screw the nozzle insulator over the diffuser and contact tip and **(hand tighten) (tighten with pliers)**.

d. Slide the nozzle over the split-spring rings of the insulator and adjust for **(nozzle length) (electrode extension)**.

Objective 19

Solve problems concerning maintenance requirements for GMAW guns by circling the number of the material that best solves each of the following problems.

a. An air cooled GMAW gun isn't performing exactly right. As you give it a maintenance check, you should:

(1) Make sure the contact tip is tight and that the contact tip is the right size for the wire being used.
(2) Check the tension on the feed rollers because this can cause a gun to malfunction.
(3) Check for leaks in the coolant line.

b. A water cooled GMAW gun isn't performing properly. As you give it a maintenance check, you should:

(1) Check the gas diffuser first.
(2) Check the contact tip.
(3) Check for hose leaks and a sufficient coolant supply.

c. A spool gun is not working properly. As you give it a maintenance check, you should:

(1) Check it out like any other GMAW gun.
(2) Check the feed roll tension because this is very important on a spool gun.
(3) Check coolant supply.

Objective 20

Select true statements concerning electrode extension and its function in GMAW by writing an "X" next to the true statements.

_____ a. Electrode extension gives an operator control of slight but critical adjustments of amperage and voltage needed to correct spatter, penetration, and bead width.

_____ b. Too much electrode extension increases amperage and slightly increases voltage; this results in more arc which produces spatter and poor penetration.

_____ c. Too little electrode extension decreases amperage and slightly decreases voltage; this results in less arc which gives no spatter and good penetration, but it produces a narrow bead with overall poor fusion.

_____ d. Electrode extension for short-circuit transfer and surface tension transfer is 1/4" to 1/2".

_____ e. Electrode extension for spray transfer is 1/2" to 1".

_____ f. Electrode extension for pulsed spray transfer is 1/2" to 3/4".

Objective 21

Complete statements concerning GMAW shielding gases and their applications by circling the correct answers.

a. Argon is the most frequently used shielding gas for welding **(nonferrous) (ferrous)** metals because it produces a clean, narrow bead with deep penetration in both short-circuit and spray transfer.

b. Helium is mixed with argon for some aluminum welding in both short-circuit and spray transfer, but helium does not produce the stable arc provided by **(CO_2) (argon)**.

c. CO_2 is used primarily on carbon steels because it is far less expensive than other shielding gases, but because CO_2 can produce an unstable arc and spatter, it requires electrode wires with **(deoxidizing agents) (flux)**.

d. Oxygen is used as a stabilizer in varying percentages with argon for spray transfer on **(both mild and stainless steels) (aluminum)**.

Written Test

Objective 22

Differentiate between GMAW welding techniques and their characteristics by placing an "F" next to items that refer to the "forehand" welding technique and a "B" next to items that refer to the "backhand" welding technique.

_____ a. With this technique, the electrode points in the direction of travel.

_____ b. With this technique, the electrode points opposite the direction of travel.

_____ c. This technique is mostly used on thinner metals.

_____ d. This technique is mostly used on thicker metals.

_____ e. This technique increases penetration, gives a more convex, narrower bead, provides a more stable arc, and leaves less spatter on the workpiece.

Objective 23

Solve problems concerning techniques for properly ending a GMAW weld by circling the number of the material that best solves each of the following problems.

a. A welder friend tells you that ending a weld is a real problem. To help the friend solve the problem, you could:

    (1) Tell the friend that practice makes perfect.
    (2) Show the friend how the backhand technique is used to end a weld.
    (3) Demonstrate to the friend how to release the gun trigger just as the bead reaches the end of the weld.

b. A friend who has been experimenting with the proper way to end a weld is still having a problem. To help the friend solve the problem, you could:

    (1) Encourage the friend to keep practicing.
    (2) Show the friend how to hold the gun in place and hesitate for just a second and then pull the gun away.
    (3) Demonstrate the forehand technique to your friend.

c. A friend who has been experimenting with properly ending a weld is having some real problems with a weld that starts in a corner. To help the friend solve the problem, you should:

    (1) Show your friend the alternate technique of reversing the travel direction before breaking the arc.
    (2) Demonstrate to your friend how the backhand technique is made to order for welding out of corners.
    (3) Tell your friend to adjust electrode extension and use a forehand welding technique.

Objective 24

Select true statements concerning techniques for position welding with GMAW by writing an "X" next to the true statements.

_____ a. For single-pass butt joints in the flat position, use a slight backstepping motion, but for flat position open-root butt joints, use a small weave.

_____ b. For fill and cover passes in the flat position, weave to desired width.

_____ c. For fillet welds in the horizontal position, use a circular weave.

_____ d. For V-groove butt joints in the horizontal position, use a weave to accomplish the desired width.

_____ e. For both single-pass and multi-pass groove welds, and for fillet welds in the vertical up position, use a weaving technique.

_____ f. For all welds in the vertical down position, take special care to keep the arc in the leading edge of the puddle so the molten metal will not run around the arc and cause cold lapping.

_____ g. For both groove and fillet welds in the overhead position, use a weaving technique.

Objective 25

Complete statements concerning conditions that require special attention with GMAW by circling the correct answers.

a. Base metal cleanliness is **(less) (more)** critical with GMAW than with some other welding processes.

b. Preweld and interpass cleaning are essential for GMAW, and especially for **(aluminum) (mild steel)** where chemical cleaning and/or mechanical removal of metallic oxides may be required.

c. The **(reduced) (increased)** heat input common to short circuit GMAW results in low penetration into the base metal, and may result in incomplete fusion if an improper welding technique is used.

d. Oil, grease, and drawing compounds on the electrode wire or the base metal can become potential sources of **(hydrogen) (oxygen)** pick-up in a base metal.

e. GMAW shielding gases should be **(high) (low)** in moisture content and the welding facility should be free of contaminants.

f. Weld problems such as undercutting, porosity, incomplete fusion, and incomplete joint penetration should be properly identified and **(evaluated) (corrected)**.

Written Test

Objective 26

Complete a chart of possible causes and corrective actions for undercutting by writing the corrective actions required in the following chart.

Undercutting	
Possible Causes	Corrective Actions
Travel speed too high	a. ______________________
Welding voltage too high	b. ______________________
Excessive welding current	c. ______________________
Gun angle	d. ______________________ ______________________

Objective 27

Complete a chart of possible causes and corrective actions for porosity by writing the corrective actions required in the following chart.

Porosity	
Possible Causes	Corrective Actions
Inadequate shielding gas coverage	a. ______________________ ______________________ ______________________
Gas contaminants	b. ______________________
Electrode contamination	c. ______________________
Workpiece contamination	d. ______________________ ______________________ ______________________
Arc voltage too high	e. ______________________
Excess contact tube-to-work distance	f. ______________________

Objective 28

Complete a chart of possible causes and corrective actions for incomplete fusion by writing the corrective actions required in the following chart.

Incomplete Fusion

Possible Causes	Corrective Actions
Weld zone surfaces not free of silt or excessive oxides	a. ______________ ______________ ______________
Insufficient heat input	b. ______________ ______________ ______________
Too large a weld puddle	c. ______________ ______________ ______________
Improper weld technique	d. ______________ ______________ ______________
Improper joint design	e. ______________ ______________ ______________
Excessive travel speed	f. ______________

Written Test

Objective 29

Complete a chart of possible causes and corrective actions for incomplete joint penetration by writing the corrective actions required in the following chart.

Incomplete Joint Penetration

Possible Causes	Corrective Actions
Improper joint preparation	a. ________________
	________________
	________________
	________________
Improper weld technique	b. ________________
	________________
	________________
Inadequate welding current	c. ________________

Objective 30

Complete a chart of possible causes and corrective actions for excessive melt-through by writing the corrective actions required in the following chart.

Excessive Melt-Through

Possible Causes	Corrective Actions
Excessive heat input	a. ________________
	________________
	________________
Improper joint preparation	b. ________________
	________________

Objective 31

Complete statements concerning flow meters and their use in GMAW by circling the correct answers.

a. Flow meters regulate the flow of **(high) (low)** pressure gases used in GMAW.

b. Flow meters measure gas flow in cubic feet per **(hour) (minute)** and are calibrated with an adjusting valve on the meter itself.

c. Floating-ball flow meters must be operated only in the **(vertical) (horizontal)** position.

d. A regulator should be used between the gas supply and the flow meter to assure **(uniform) (maximum)** input pressure to the flow meter.

e. Gas mixtures are available in single cylinders, but gas from separate cylinders can be used with percentages calibrated through **(a mixer) (dual regulators)**.

Objective 32

Select true statements concerning flow rates for GMAW shielding gases by writing an "X" next to the true statements.

_____ a. Flow rates for GMAW shielding gases are subject to two main variables.

_____ b. Metal thickness and joint design are the major considerations.

_____ c. As welding progresses, electrode extension, travel speed and angle, and environmental conditions may dictate flow rate changes.

Objective 33

Solve problems concerning guidelines for troubleshooting GMAW problems by circling the number of the material that best solves each of the following problems.

a. A coworker at another welding station is having trouble with electrical settings and has changed the amperage and slope settings on the welding machine. The problem seems to be worse. How can you help your coworker?

(1) Let the other worker solve the problems alone, it is the only way anyone really learns.
(2) Suggest that all controls be turned back to their original settings, and then change only one variable at a time.
(3) Have the worker continue changing other settings until the problem is solved.

b. A coworker has a problem with gas flow and immediately shuts the equipment down and starts to replace the gas solenoid valve. How can you help your coworker?

(1) Lend the worker a hand with changing out the valve.
(2) Suggest that the worker check the regulator first.
(3) Suggest that the worker check the gas cylinder to make sure it still has gas in it.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 10
b. 3
c. 16
d. 1
e. 14
f. 2
g. 11
h. 8
i. 15
j. 9
k. 12
l. 13
m. 5
n. 4
o. 7
p. 6

Objective 2

a. Direct
b. Low, small
c. Thin
d. No metal
e. Argon

Objective 3

a. Greater
b. Only slightly
c. Short-circuiting
d. Gravity alone
e. Mild steels

Objective 4

a. Direct, positive
b. 80%
c. Increases above
d. Smaller
e. Less

Objective 5

a. Low, high
b. Thin
c. Higher

Objective 6

a. Independent of
b. Instantaneous
c. Logical

Objective 7

a. 3
b. 6
c. 5
d. 7
e. 1
f. 4
g. 2

Objective 8

a. 1
b. 6
c. 5
d. 4
e. 7
f. 9
g. 8
h. 3
i. 2

Objective 9

a. 10
b. 3
c. 5
d. 7
e. 8
f. 2
g. 11
h. 4
i. 9
j. 1
k. 6

Answers to Written Test

Objective 10	a. 2 b. 2
Objective 11	b, d
Objective 12	a, c, e
Objective 13	a. 8 b. 4 c. 3 d. 6 e. 1 f. 5 g. 2 h. 7
Objective 14	a. 3 b. 2 c. 1 d. 3 e. 1
Objective 15	a, c
Objective 16	a. Short-circuit b. Maximum c. Wire feed unit d. Reel e. Aluminum
Objective 17	a. 2 b. 3 c. 1 d. 4
Objective 18	a. An adjustable wrench b. Pliers c. Hand tighten d. Electrode extension
Objective 19	a. 1 b. 3 c. 2
Objective 20	a, d, f
Objective 21	a. Nonferrous b. Argon c. Deoxidizing agents d. Both mild and stainless steels

Answers to Written Test

Objective 22

a. F
b. B
c. B
d. F
e. B

Objective 23

a. 3
b. 2
c. 1

Objective 24

a, b, c, d, e, f, g

Objective 25

a. More
b. Aluminum
c. Reduced
d. Hydrogen
e. Low
f. Corrected

Note: Student answers for Objectives 26 through 30 should approximate those given.

Objective 26

a. Reduce travel speed.
b. Reduce voltage.
c. Reduce wire feed speed.
d. Change gun angle so that arc force can aid in metal placement.

Objective 27

a. Increase gas flow to displace air from the weld zone, or decrease gas flow to avoid turbulence and air entrapment in the weld zone.
b. Use welding grade shielding gases.
c. Use only clean, dry electrode wire.
d. Perform better preweld cleaning. Use more highly deoxidizing electrode wire.
e. Reduce voltage.
f. Reduce electrode extension.

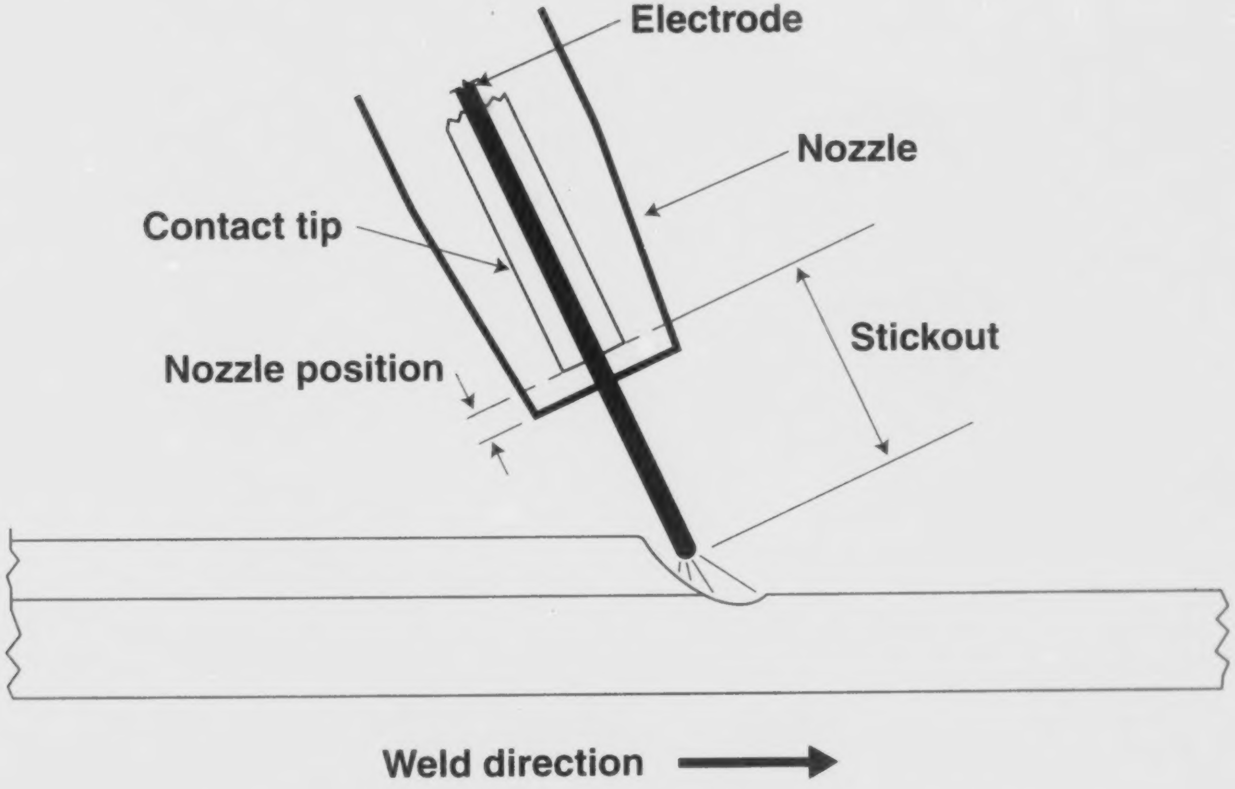
Objective 28

a. Clean weld zone surface free of mill scale before welding.
b. Increase wire feed speed and arc voltage, and reduce electrode extension.
c. Minimize weaving to produce a more controllable weld puddle. Increase travel speed.
d. Keep electrode directed at the leading edge of the puddle. When weaving, dwell momentarily on the side walls of grooves. Provide improved access to roots of joints.
e. Use angle groove large enough to allow access to bottom of the groove and sidewalls with proper extension, or use "U" or "J" groove.
f. Reduce travel speed.

Answers to Written Test

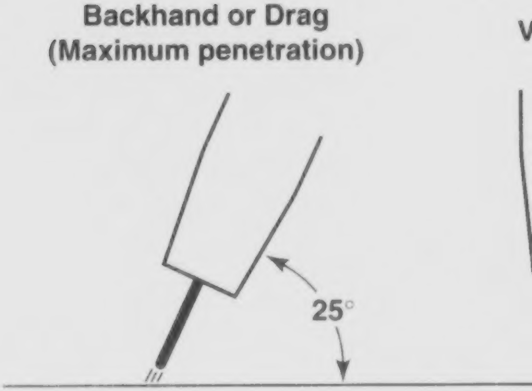
Objective 29	a. Provide proper access to the bottom of the groove while maintaining proper electrode extension. Reduce excessively large root face. Increase the root gap in butt joints, and increase the depth of back gouge. b. Maintain electrode angle normal to work surface to achieve maximum penetration. Keep arc on leading edge of puddle. c. Increase the wire feed speed.
Objective 30	a. Reduce wire feed speed and voltage. Increase travel speed. b. Reduce root opening. Increase root face dimensions.
Objective 31	a. Low b. Hour c. Vertical d. Uniform e. A mixer
Objective 32	c
Objective 33	a. 2 b. 3

GMAW Contact Tip Position


Electrode
Nozzle
Contact tip
Stickout
Nozzle position
Weld direction

Courtesy of Lincoln Electric Company.

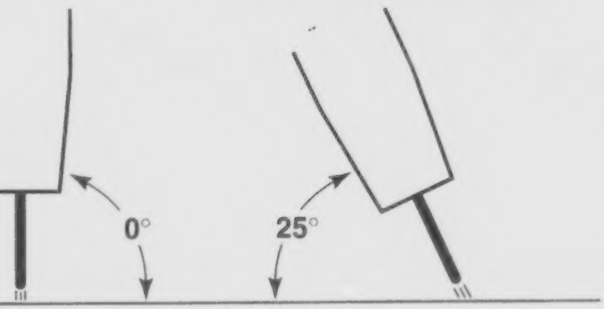
GMAW T


Backhand or Drag
(Maximum penetration)
25°
V

Weld direct

Courtesy of Lincoln Electric Company.

ravel Angle

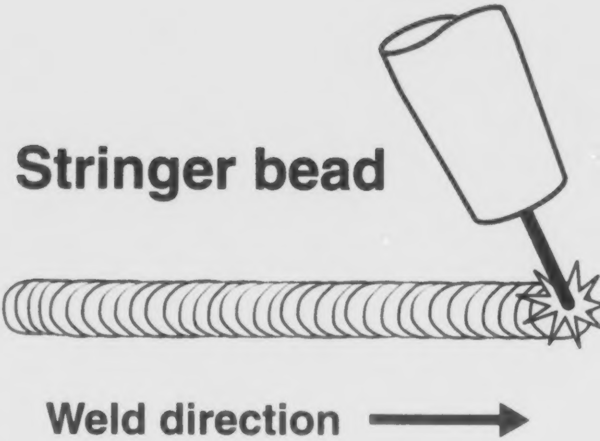


rtical

**Forehand or Push
(Minimum penetration)**

on ⟶

GMAW Be

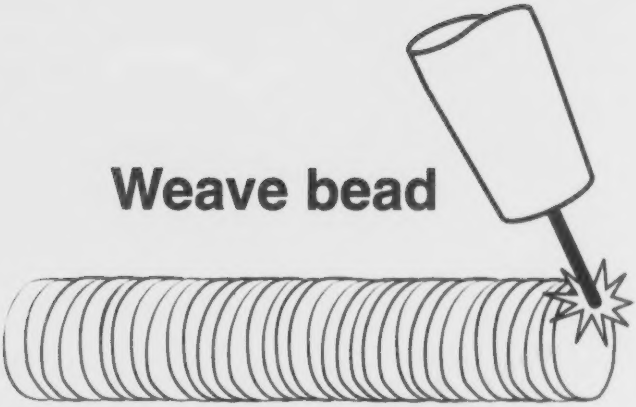


Stringer bead

Weld direction →

Courtesy of Lincoln Electric Company.

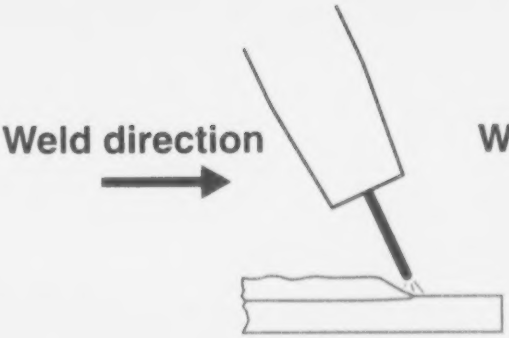
ead Formation



Weave bead

Weld direction →

GMAW Be

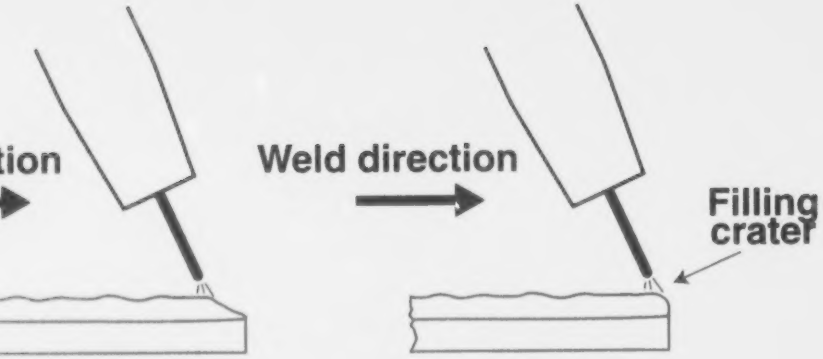

Weld direction

Step 1

Weld direct

Courtesy of Lincoln Electric Company.

ead Termination



tion

Weld direction

Filling crater

Step 2

Step 3

Major Advantages of STT

Low Heat Input → Reduced Distortion

Minimal Spatter → Reduced Cleaning

Bead Contour → Less Grinding

Process Efficiency → Fusion Even on Gaps

Over Welding → Smaller Welds

Uses Larger Wire → Lower Cost

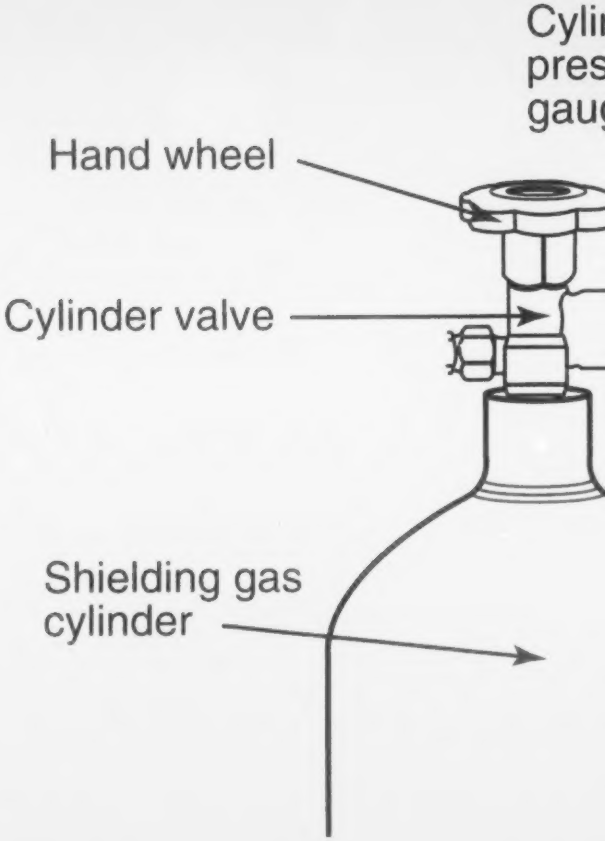
Can Use CO_2 → Lower Cost

Easy → Minimal Training

Environmental → Less Smoke

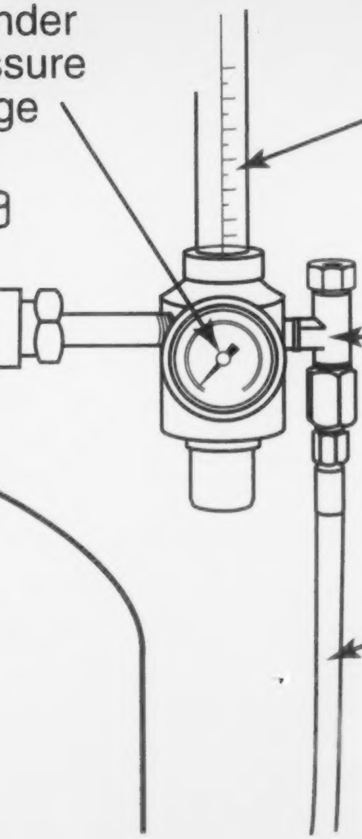
Courtesy of Lincoln Electric Company.

Flow


Cylin
pres
gaug
Hand wheel
Cylinder valve
Shielding gas cylinder

Copyright © 2000 Lincoln Global Inc.

Meter


nder
ssure
ge
Flow meter
Flow
control
valve
Shielding
gas hose

Unit 3 Flux-Cored Arc Welding

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 3–3

Written Test 3–7

Answers to Written Test 3–15

Teacher Supplement

1—A Brief History of FCAW 3–17

Transparency Masters

1—FCAW Equipment 3–19
2—FCAW Electrode Stickout 3–21
3—FCAW Contact Tip Position 3–23
4—FCAW Travel Angle 3–25
5—FCAW Bead Initiation 3–27
6—FCAW Bead Formation 3–29
7—Principles of the FCAW-GS Process 3–31
8—AWS Classification of Flux-Cored Wires 3–33

Student Page

Student Components

Learning Activities Sheet 3–3

Objective Sheet 3–9

Information Sheet 3–11

Student Supplements

1—Typical Operating Variables for Flux-Cored Electrodes 3–23
2—FCAW-GS Electrodes 3–25
3—AWS Classifications for FCAW Electrodes 3–27
4—FCAW Troubleshooting 3–29

*Job Sheets

1—Set Up or Replace Wire on a Flux-Cored Wire Feeder 175
2—Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding 179
3—Prepare Mild Steel for FCAW 181
4—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 183
5—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 187

Unit Contents

6—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 191
7—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 195
8—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position 199
9—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position 203
10—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position 207
11—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position 211
12—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 215
13—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position 219
14—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position 223
15—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position 227

*Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet located in the student edition. Modify as appropriate to include additional activities and/or resources available in your classroom.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Review welding techniques from Unit 2, "GMAW Equipment, Applications, and Techniques." Also review how to crater and fill to end a weld. Show the similarities of the gas metal arc and flux-cored arc welding processes.

- Take time to demonstrate the variables discussed in Objective 13. Encourage students to keep the variables in mind as they begin the job sheets that accompany this unit.

- Demonstrate the procedures in the job sheets. Point out the care demanded when handling flux-cored wires, especially that flux-cored wire will flatten out much easier than the hard wires used in GMAW. Also, demonstrate how to use CO_2 as a shielding gas with FCAW, and modify job sheets as needed if you have students work with a shielding gas.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Technology, Welding Handbook*. 8th ed. Vol. 1. Miami, FL: American Welding Society, 1987.
- *FCAW-GS*. Cleveland, OH: Lincoln Global Inc., 2000.
- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*. 8th ed. Vol. 2. Miami, FL: American Welding Society, 1991.
- *The Procedure Handbook of Arc Welding*. 13th ed. Cleveland, OH: The Lincoln Electric Company.
- *Welding & Fabricating Data Book*, 1988/89. Cleveland, OH: Penton Publishing, Inc., 1988.

Suggested Supplemental Resources

Print Media

- *Everyday Pocket Handbook for Gas Metal Arc and Flux Cored Arc Welding* (PHB-4)—FCAW portion of this handbook includes specification and classification system for FCAW electrodes and troubleshooting advice for mechanical and electrical FCAW. Available from:

  American Welding Society
  550 N.W. LeJeune Road
  Miami, FL 33126
  800.443.9353
  www.aws.org

Suggested Activities

Electronic Media

- Videos
  - Tape 4: *Gas Metal, Flux Cored-Arc Welding (MIG)*—This 24-minute video is part of a four-tape series called *Arc Welding Explained.* Program activity sheets are available for the viewer to fill out during "stop slates" in the video program. A CD-ROM is also available that includes the series videos, pre and post test questions, and video glossary. ISBN 0-8064-1366-2
  - *Flux Cored Arc Welding Video Series*, 1st edition, ©2001—This set of four videos introduces students to essential flux cored arc welding principles and techniques. Step-by-step instruction in each video is aimed at assisting viewers in developing basic hand skills. Live action, close-ups, and step-by-step animations are featured. The importance of safety, as well as the proper use of safety equipment, is also stressed. Available on VHS cassettes, or CD-ROM, this series also features a set of corresponding activity sheets to help viewers apply what they have seen on each video to the welding shop. Videos and CDs may be purchased separately or as a complete set. ISBN/ISSN 0-7668-2292-3.

    The videos listed above are available from:

    Delmar Publishing
    3 Columbia Circle
    P.O. Box 15015
    Albany, NY 12212-5015
    800.347.7707
    www.delmar.com

  - *Flux Cored Arc Welding, FCAW* (V12.0)—Includes 20 topics. Available from:

    Hobart Institute of Welding Technology
    400 Trade Square East
    Troy, OH 45373
    800.332.9448
    www.welding.org

122

Written Test

Name ____________________

Date __________ __________ Score __________

Objective 1

Match the terms with their definitions.

1. Automatic
2. Concentric
3. FCAW
4. Gas-shielded
5. Self-shielded
6. Semiautomatic

_____ a. An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux in the tubular electrode, and additional shielding may be obtained from an externally supplied gas

_____ b. A flux-cored wire electrode used in the presence of a shielding gas to provide double protection and improved mechanical properties for the weld zone

_____ c. A flux-cored wire electrode that protects the weld zone from contaminants with fluxing elements released from the inner core of the wire itself as the arc is made

_____ d. An FCAW process where welding is controlled by mechanical devices programmed for specific applications

_____ e. An FCAW process where welding is controlled as an operator squeezes or releases a gun trigger

_____ f. Having a common center or a common axis

Objective 2

Select true statements concerning advantages of FCAW by placing an "X" in the blanks next to the true statements.

_____ a. FCAW can weld many metals over a wide thickness range, and create less distortion than SMAW.

_____ b. With FCAW, the visible arc makes for easy application with less effort on the part of the welder.

_____ c. FCAW is time-saving because it requires less precleaning than GMAW.

_____ d. FCAW produces a smooth, uniform weld with excellent appearance.

_____ e. FCAW has a lower tolerance for contaminants that may cause weld cracking.

_____ f. With self-shielding electrodes, FCAW is constantly bothered by breezes and drafts, but with gas shielded applications, wind is not a problem.

Objective 3

Select true statements concerning limitations of FCAW by placing an "X" in the blanks next to the true statements.

_____ a. FCAW is currently limited to welding nonferrous metals and nickel base alloys.

_____ b. FCAW equipment is more expensive and more complex than SMAW equipment, but increased productivity usually compensates for added FCAW costs.

_____ c. The FCAW wire feeder and power source must be fairly close to the point of welding.

_____ d. FCAW does not require cleanup after welding, and the process does not create smoke in the workplace.

Objective 4

Complete statements concerning how students benefit from learning FCAW by circling the correct answers.

a. The FCAW process introduces students to high **(speed) (deposition)** welding.

b. With FCAW, students learn **(manipulative) (setup)** skills for the fast welding speeds required for production-type welding.

c. Students who master FCAW will have additional opportunities because the FCAW process is **(the most important) (popular)** in industry, and its use will continue to expand.

Objective 5

Select true statements concerning equipment required for semiautomatic self-shielded FCAW by placing an "X" in the blanks next to the true statements.

_____ a. The FCAW process requires a constant voltage AC power source with a maximum amperage range of 200 to 400 amps.

_____ b. The process only requires an electrode input cable and a work cable.

_____ c. FCAW requires a reel of continuous electrode wire and an electrode feed unit.

_____ d. FCAW requires a gun and cable assembly.

Objective 6

Match the types of flux-cored arc welding processes with their characteristics.

1. Automatic self-shielded
2. Gas-shielded flux-cored
3. Semiautomatic self-shielded

_____ a. A modification of the manual shielded metal-arc welding process except that the covered SMAW electrode is replaced with a continuous flux-cored electrode that is fed through a gun instead of an electrode holder

_____ b. A welding process similar to both SMAW and GMAW, but different than SMAW in that CO_2 is usually used as a shielding gas in a dual function with the electrode flux, and different from GMAW in that the electrode wire is tubular instead of solid

_____ c. A modification of the semiautomatic self-shielded process that replaces manual manipulation with programmed, mechanized components

Objective 7

Complete statements concerning the types of FCAW guns and their uses by circling the correct answers.

a. Straight-nozzle guns are used for the self-shielded process, mostly on **(fillet) (groove)** welds and on applications where the work flows **(under) (in front of)** the gun.

b. Curved-nozzle guns are used in the self-shielding process, mostly for welding **(nonferrous) (heavy)** metals because curved nozzle guns are flexible and easy to manipulate.

c. Air-cooled and water-cooled guns are used for the gas-shielded process with **(air-cooled) (water-cooled)** guns generally used for operations up to 600 amps, and **(air-cooled) (water-cooled)** guns for operations over 600 amps.

d. **(Air-cooled) (Water-cooled)** guns are used for automatic processes where side shielding is required, and **(air-cooled) (water-cooled)** guns are used for automatic processes where concentric shielding is required.

Written Test

Objective 8

Solve problems concerning classifications for FCAW electrode wires by circling the number of the material that best solves each of the following problems.

a. You are examining a spool of electrode wire and want to be certain it is designed for flux-cored welding. You should:

   (1) Look for an "E" in the number so you will know it is the right electrode wire.
   (2) Look for a 3, 4, or 6 in the number to indicate the electrode has tubular construction.
   (3) Look for a "T" in the number to indicate that the spool contains tubular flux-cored wire.

b. You know that a welding application calls for flux-cored welding in the flat position. You should:

   (1) Check for "0" in the wire number because this indicates the wire can be used in both the flat and horizontal positions.
   (2) Check for a "1" in the wire number because like all other electrodes, this indicates the flat position.
   (3) Look for the letter "F" in the wire number because "F" indicates the flat position.

c. You are checking for an electrode wire number identification and you find a "T-3" as the final entries. You should:

   (1) Evaluate the 3 as indicating the chemical composition of the electrode.
   (2) Evaluate the 3 as indicated not only the chemical composition of the electrode, but also a self-shielded electrode.
   (3) Evaluate the 3 as indicating not only the chemical composition of the electrode and the fact that it is a self-shielded electrode, but also an electrode to use with fast wire-feed speeds and high amperage.

Objective 9

Differentiate between electrode extension and visible electrode extension by placing an "E" next to the definition of electrode extension and a "V" next to the definition of visible electrode extension.

_____ a. The length of the electrode from the contact tip within the nozzle to the workpiece

_____ b. The length of the electrode between the end of the nozzle and the workpiece

Objective 10

Solve problems concerning basic types of flux-cored wire feeders by circling the number of the material that best solves each of the following problems.

a. You're setting up for a flux-cored operation that has a long, linear weld specified. You should:

(1) Select an integrated wire feeder on a dolly so it can be moved along the workpiece.
(2) Select a remote wire feeder so you can keep the gun as close to the workpiece as possible.

b. You're setting up for a flux-cored operation that requires out-of-position welding in a confined area. You should:

(1) Select an integrated wire feeder and position it as close to the confined area as possible.
(2) Select a remote wire feeder so you can move the control unit close to the confined area.

Objective 11

Select true statements concerning guidelines for using drive rolls and guide tubes by placing an "X" in the blanks next to the true statements.

_____ a. Drive rolls and guide tubes for wire feeders have the wire sizes for which they are designed stenciled on them; use only the wires that are specified.

_____ b. Clean drive rolls and guide tubes on a weekly schedule.

_____ c. Remove accumulated dirt and shavings with a special cleaning solvent, but do not use a wire brush on a drive roll.

_____ d. Some worn drive rolls can be reversed, but when drive rolls are badly worn, replace them.

_____ e. When drive rolls slip while being fed into the cable, check to see if the end of the wire has been improperly prepared or check for shavings that may build up in the cable.

Objective 12

Arrange in order the steps for starting an arc with the semiautomatic process by placing a "1" beside the first step, a "2" beside the second step, and arrange other steps in their order.

_____ a. Cut the end of the wire.

_____ b. Position the tip of the electrode just off or just barely touching the base metal.

_____ c. Even when a long electrode extension is desired, start with about 1/2" of visible electrode extension, establish the arc as outlined, then increase the stickout to the desired length.

______ d. Inch the electrode out beyond the nozzle to just short of the visible electrode extension recommended for the electrode size and guide tip.

______ e. Allow the arc to fully establish itself, then slowly pull the gun back until the recommended electrode extension is established.

______ f. Squeeze the trigger to start the arc, but do not push the electrode into the joint as it starts to burn away.

Objective 13

Complete statements concerning operating variables with flux-cored electrode wires by circling the correct answers.

a. Arc voltage—When all other variables are held constant, arc voltage variations will have these effects:

(1) **(High) (Low)** arc voltage will produce a wider and flatter bead.
(2) **(Low) (Excessive)** arc voltage will tend to produce porosity.
(3) **(Low) (High)** voltage tends to produce a convex, ropey bead.
(4) Extremely **(low) (high)** voltage will cause the wire to stub on the plate or cause the wire to pierce the plate, strike the joint bottom, and push the gun up.

b. Current—When all other variables are held constant, current variations will have these effects:

(1) **(Decreasing) (Increasing)** current will increase melt-off and deposition rate.
(2) **(Excessive) (Too little)** current will produce a convex bead that looks bad and wastes metal.
(3) **(Low) (High)** current will result in reduced penetration.

c. Travel speed—When all other variables are held constant, travel speed variations will have these effects:

(1) **(Excessive) (Slow)** travel speed makes the bead concave with uneven edges.
(2) **(Too fast) (Too slow)** a travel speed produces slag inclusions and a rough, uneven bead.

d. Electrode extension—When all other variables are held constant, electrode extension variations will have these effects:

(1) **(Increased) (Decreased)** extension decreases current and decreased extension increases current.
(2) **(Increased) (Decreased)** extension lowers voltage across the arc, the lower arc voltage makes the bead more convex, and the tendency for porosity is reduced.
(3) **(Long) (Short)** extension gives greater penetration than long extension.

Objective 14

Solve problems concerning guidelines for preparing for FCAW applications by circling the number of the material that best solves each of the following problems.

a. A coworker is preparing to start welding on a workpiece that obviously has oil on it. The welder claims the oil will not be a problem because it will burn off. You should observe:

   (1) There is no problem. The oil will burn off.
   (2) There is a problem. The oil will cause fumes in the work area.
   (3) There is a problem. Oil on the workpiece could contribute to porosity in the weld.

b. You are sure all of your electrical settings are proper and you have the correct electrode extension, but you still get a convex or ropey-looking bead. This should be a clue to:

   (1) Check the electrode wire.
   (2) Check electrode extension once again.
   (3) Move the ground clamp to a different location and make sure you have good metal-to-metal contact.

Objective 15

Select true statements concerning guidelines for semiautomatic FCAW by placing an "X" in the blanks next to the true statements.

_____ a. Obtain a good bead shape by using the lowest voltage possible without causing porosity.

_____ b. To maintain a good bead shape, always increase arc voltage when you increase current.

_____ c. Remember that travel speed is almost always slower with self-shielded flux-cored electrodes than with SMAW electrodes because of the high deposition rate.

Objective 16

Complete statements concerning safety requirements for FCAW by circling the correct answers.

a. Use personal safety **(preferences) (clothing and equipment)** when working with FCAW equipment.

b. Follow procedures for safely operating machines and **(gun) (electrical)** components at all times.

c. When working with flux-cored wires that produce excessive smoke and fumes, use a **(welding gun with a smoke removal attachment) (a portable exhaust cape)**.

d. Sparks generated by the FCAW process can be excessive and erratic, so screen the welding area from nearby **(equipment) (workers)** and people passing by.

Written Test

Objective 17

Solve problems concerning guidelines for troubleshooting FCAW problems by circling the number of the material that best solves each of the following problems.

a. You've been asked to evaluate a flux-cored weld. You should:

   (1) Look for problems with porosity. Porosity is a big FCAW problem.
   (2) Look for smooth, uniform bead appearance that FCAW should deliver.
   (3) Look for undercutting, especially if it is a V-groove weld.

b. You've been asked to troubleshoot a welding problem that is causing weld porosity. You should:

   (1) Immediately suspect a problem with the electrode wire.
   (2) Immediately suspect a problem with a beginning welder.
   (3) Try to isolate the problem to a logical source.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1	a. 3 b. 4 c. 5 d. 1 e. 6 f. 2
Objective 2	a, b, c, d
Objective 3	b, c
Objective 4	a. Deposition b. Manipulative c. Popular
Objective 5	c, d
Objective 6	a. 3 b. 2 c. 1
Objective 7	a. Fillet, under b. Heavy c. Air-cooled, water-cooled d. Air-cooled, water-cooled
Objective 8	a. 3 b. 1 c. 3
Objective 9	a. E b. V
Objective 10	a. 1 b. 2
Objective 11	a, d, e
Objective 12	a. 2 b. 3 c. 6 d. 1 e. 5 f. 4

Answers to Written Test

Objective 13

a. 1. High
   2. Excessive
   3. Low
   4. Low
b. 1. Increasing
   2. Excessive
   3. Low
c. 1. Excessive
   2. Too slow
d. 1. Increased
   2. Increased
   3. Short

Objective 14

a. 3
b. 3

Objective 15

b

Objective 16

a. Clothing and equipment
b. Electrical
c. Welding gun with a smoke removal attachment
d. Workers

Objective 17

a. 2
b. 3

Teacher Supplement 1—A Brief History of FCAW

1. The FCAW process was developed because of the great potential offered by a process that could use a self-shielded electrode fed from a continuous coil supply in a mechanized process.

2. Early experiments with covered electrode coiled and fed from a reel were not successful because the flux covering tended to crack too easily.

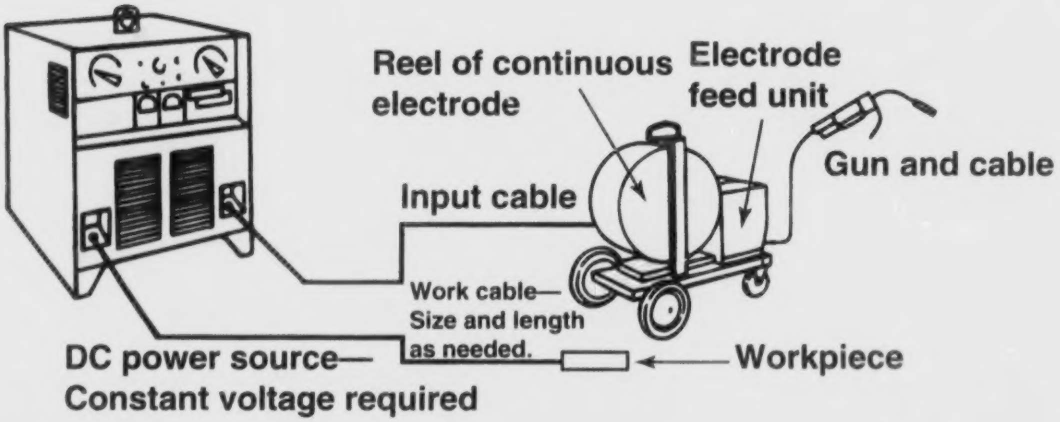
3. In the mid-1950's, the CO_2 shielding was combined with a flux-containing tubular electrode which overcame many of the problems encountered previously. Operating characteristics were improved by the addition of the core materials and weld quality was improved by eliminating atmospheric contamination.

4. In 1958, the Lincoln Electric Company introduced a process that turned the electrode wire "inside out" so that the flux materials were inside a tubular wire.

5. Lincoln referred to their process as Innershield®. They developed self-shielding electrode wire that permitted use of higher amperages and provided greater deposition rate for production-type applications.

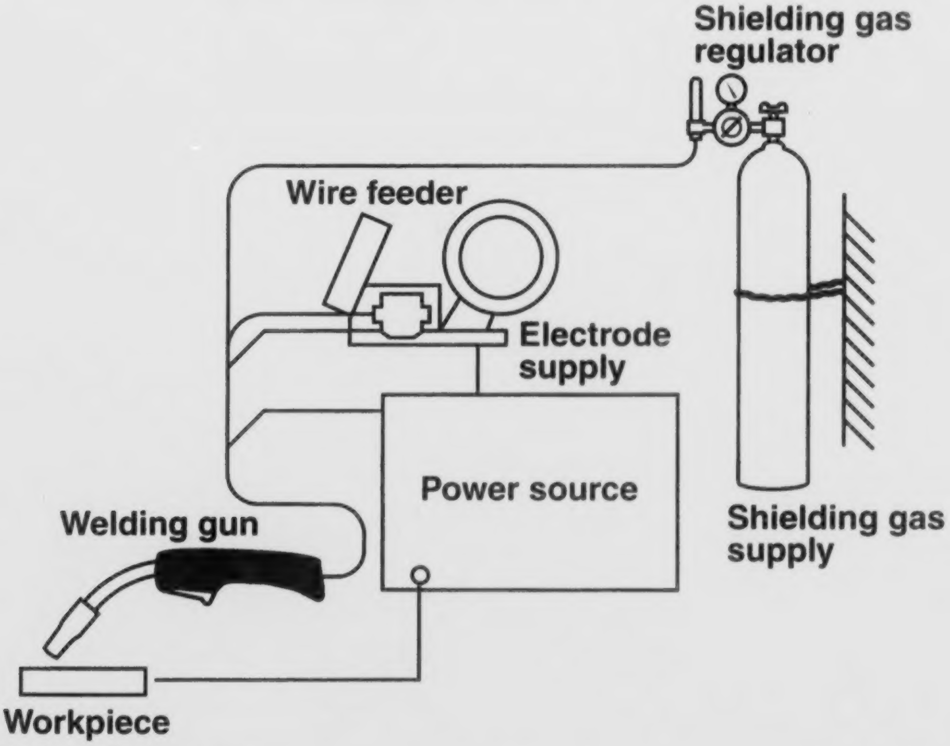
FCAW Equipment

Semiautomatic Self-Shielded FCAW


Reel of continuous electrode
Electrode feed unit
Gun and cable
Input cable
Work cable—Size and length as needed.
Workpiece
DC power source—Constant voltage required

Courtesy of Lincoln Electric Company.

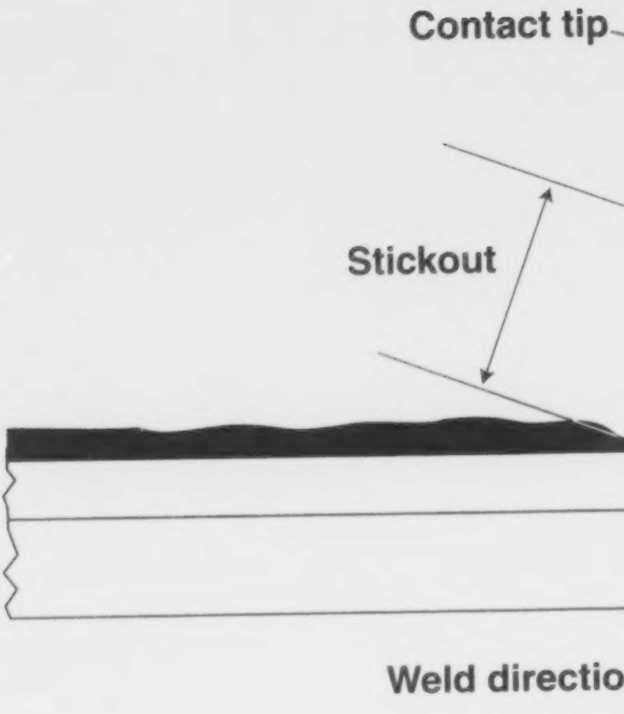
Gas-Shielded FCAW


Shielding gas regulator
Wire feeder
Electrode supply
Power source
Shielding gas supply
Welding gun
Workpiece

Copyright © 2000 Lincoln Global Inc.

MAVCC—*Gas Metal Arc Welding and Flux-Cored Arc Welding*

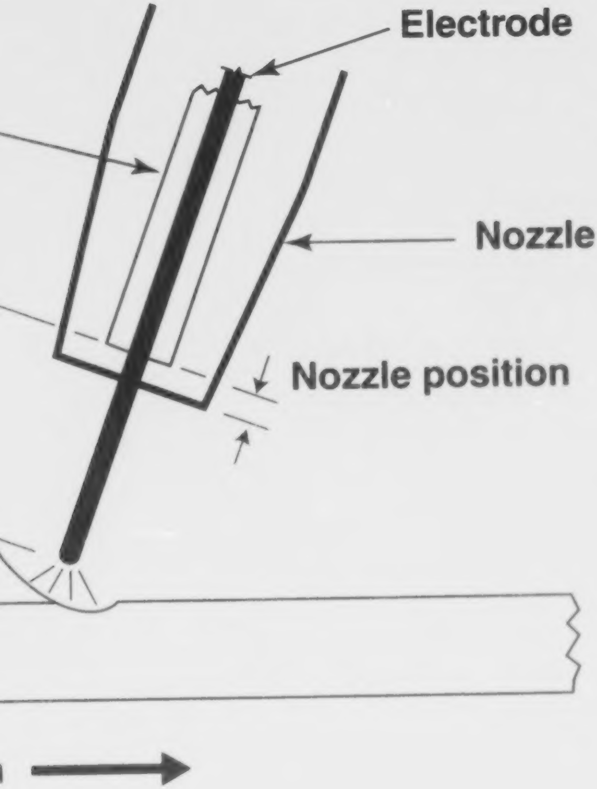
FCAW Elec


Contact tip
Stickout
Weld directio

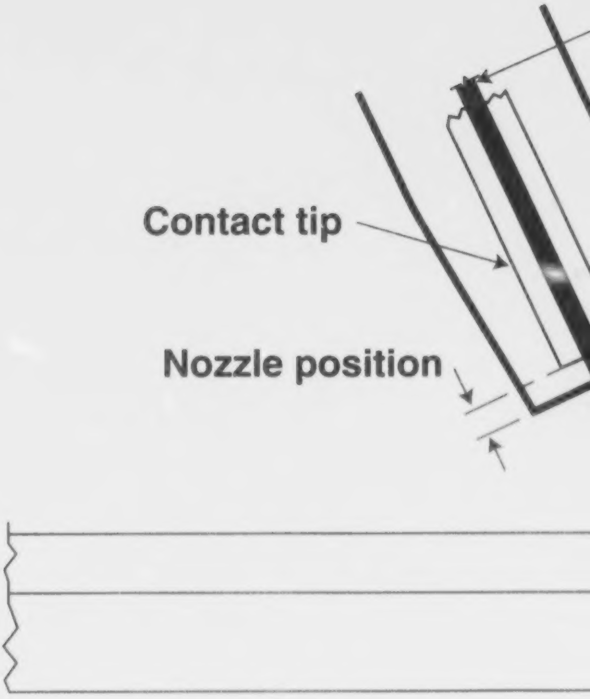
Copyright © 2000 Lincoln Global Inc.

TM 2
T 3–21

trode Stickout


Electrode
Nozzle
Nozzle position

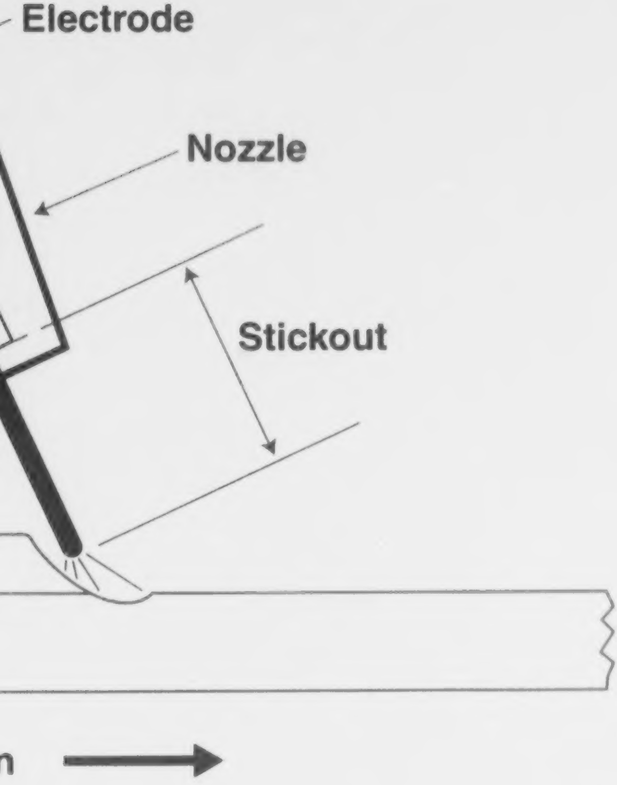
FCAW Cont


Contact tip
Nozzle position

Weld directi

Copyright © 2000 Lincoln Global Inc.

ct Tip Position


Electrode
Nozzle
Stickout
n

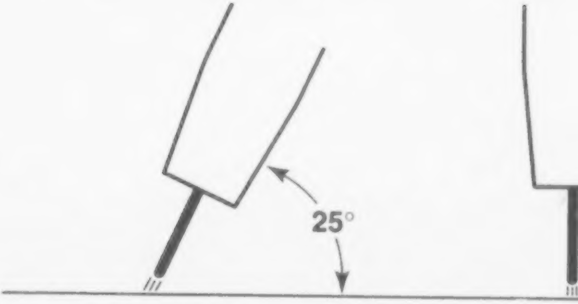
MAVCC—*Gas Metal Arc Welding and Flux-Cored Arc Welding*

FCAW Tr

FCAW-SS

Backhand or Drag
(Maximum penetration)

Vert



Weld directio

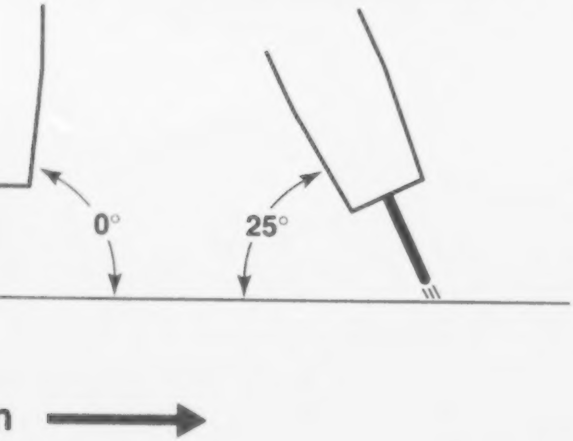
Copyright © 2000 Lincoln Global Inc.

avel Angle

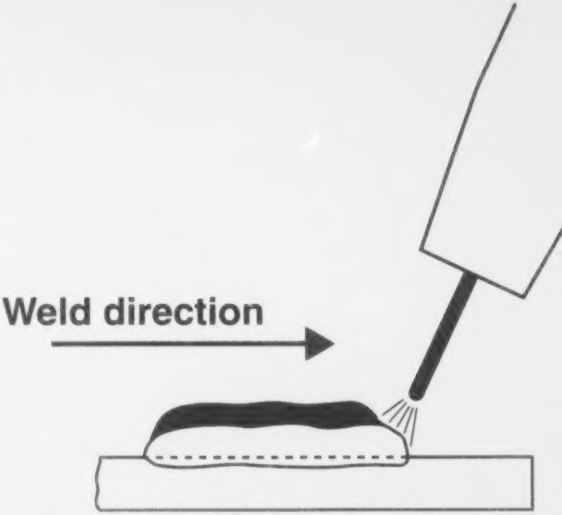
FCAW-GS

ical

Forehand or Push
(Minimum penetration)



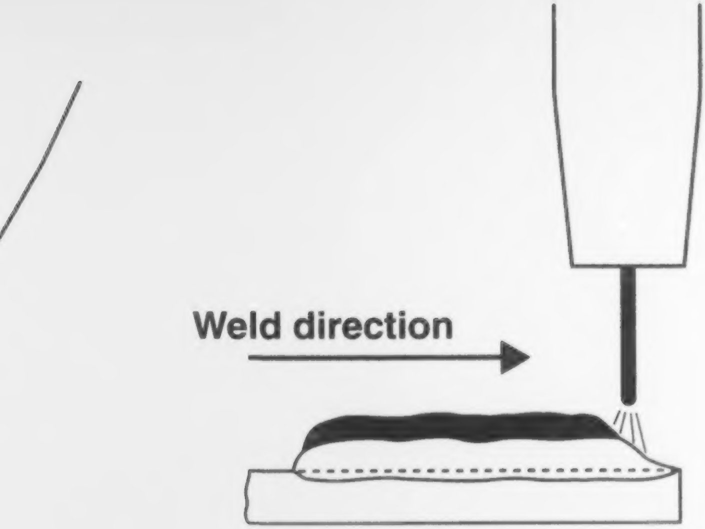
FCAW Be


Weld direction

Step 1

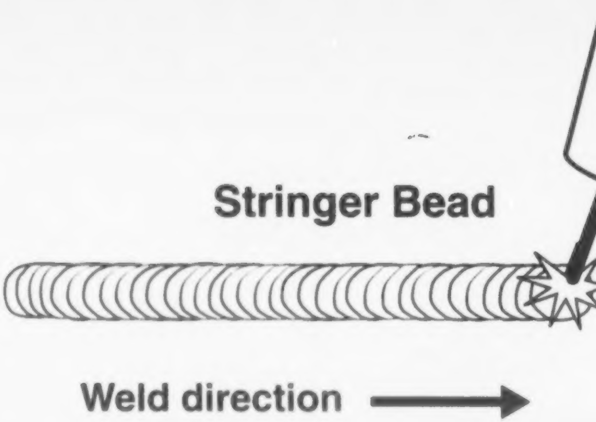
Copyright © 2000 Lincoln Global Inc.

ead Initiation


Weld direction

Step 2

FCAW B

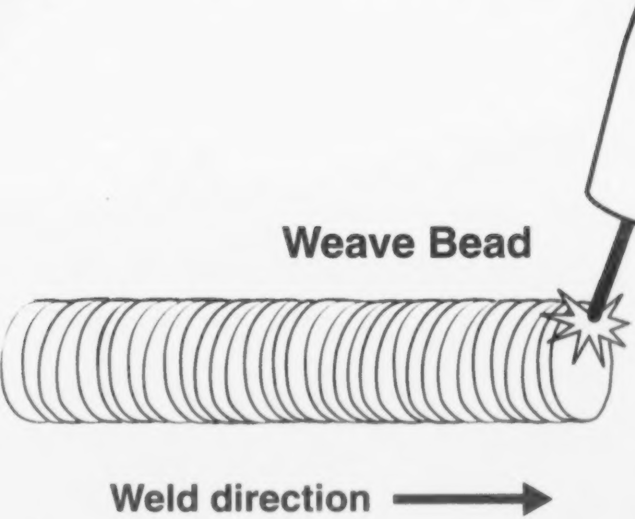


Stringer Bead

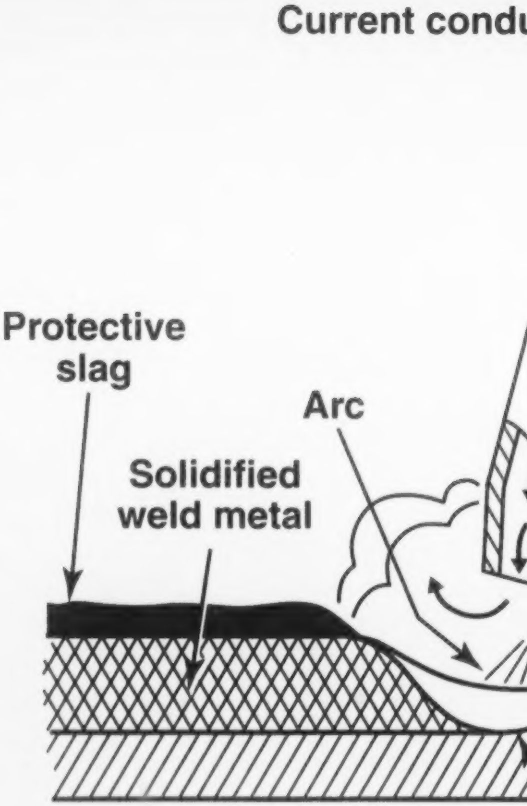
Weld direction →

Copyright © 2000 Lincoln Global Inc.

ead Formation

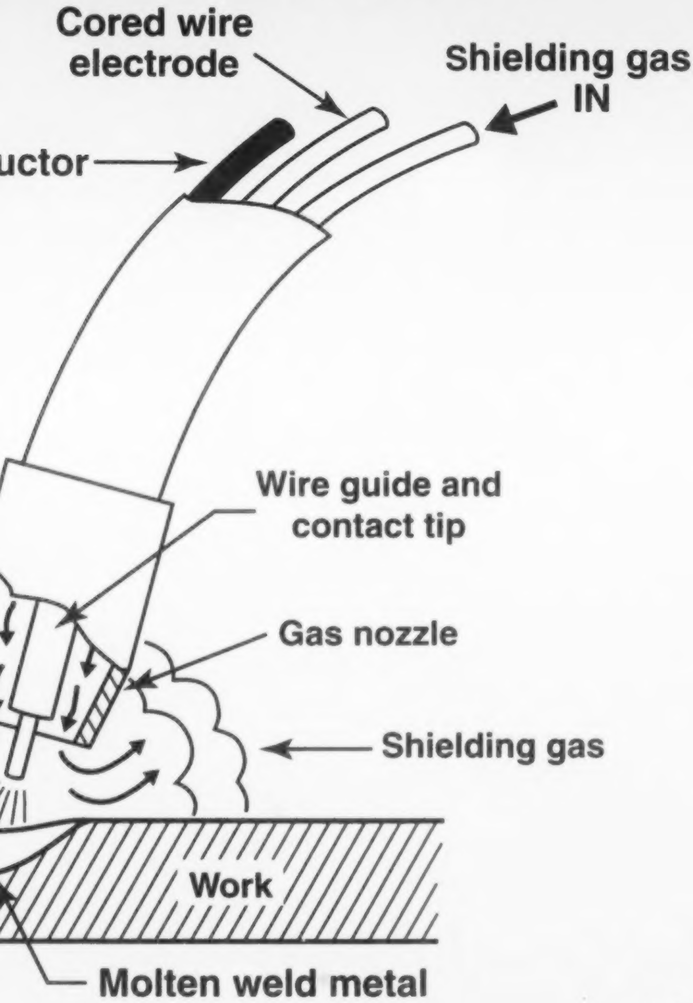

Weave Bead
Weld direction

Principles of the


Current condu
Protective slag
Arc
Solidified weld metal

Copyright © 2000 Lincoln Global Inc.

e FCAW-GS Process


Cored wire electrode
Shielding gas IN
uctor
Wire guide and contact tip
Gas nozzle
Shielding gas
Work
Molten weld metal

AWS Classificatio

Electrode ———

70,000 psi Min. Tensil

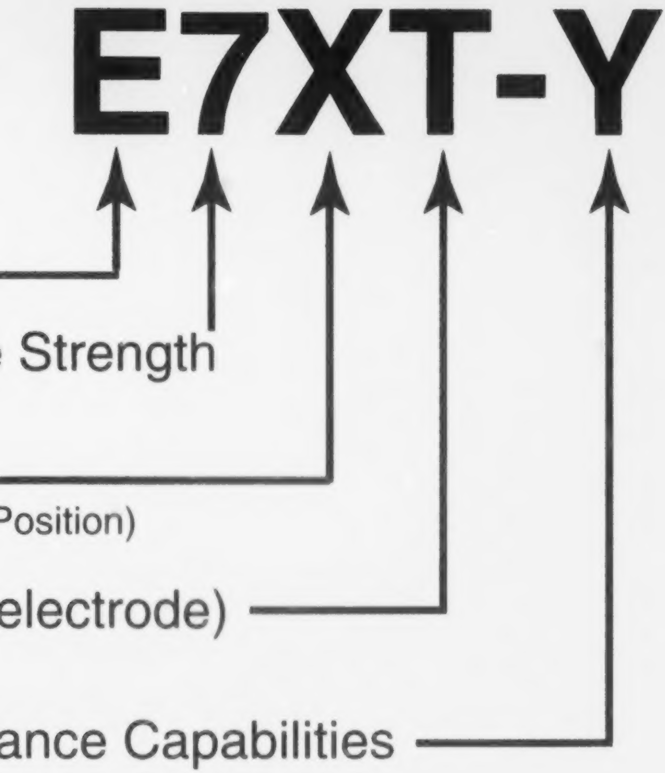
Welding Position —
(O=Flat & Horizontal, 1=All

Tubular (Flux-cored

Usability & Perform

Copyright © 2000 Lincoln Global Inc.

on of Flux-Cored Wires



E7XT-Y

e Strength

Position)

electrode)

ance Capabilities

Gas Metal Arc Welding and Flux-Cored Arc Welding

THIRD EDITION

MAVCC

Student Edition

CE081768

1-014933

60040

BEST COPY AVAILABLE

Gas Metal Arc Welding and Flux-Cored Arc Welding

Third Edirion

Student Edition

Written by

Clarence Fortney
Mike Gregory
and
Larry New

Revised by

John Knapp
and
Eddie Harper

Project coordinated by

Cheryl Barr

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

©2001

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

01-014933 600402

©2001 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Cover art courtesy of Lincoln Electric Company.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Gas Metal Arc Welding and Flux-Cored Arc Welding

Student Edition

Table of Contents

Units of Instruction

Unit 1: GMAW Orientation and Safety

Unit 2: GMAW Equipment, Applications, and Techniques

Unit 3: Flux-Cored Arc Welding

Unit 1 GMAW Orientation and Safety

Unit Contents

Student Components

	Student Page
Learning Activities Sheet	1–3
Objective Sheet	1–5
Information Sheet	1–7
*Assignment Sheet	
1—Solve Problems Concerning GMAW Safety	1

*The Assignment Sheet is located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 6.

Optional

☐ 4. **View** Videotape entitled *Health and Safety Factors in Welding.*

☐ 5. **Study** Information Sheet, Objectives 7 and 8.

Optional

☐ 6. **Research** Online resources regarding NEMA classifications. Visit www.nema.org as one of your sources.

Optional

☐ 7. **View** Videotape entitled *Health Factors in Welding Operations.*

☐ 8. **Study** Information Sheet, Objectives 9 through 16.

☐ 9. **Do** Assignment Sheet 1, "Solve Problems Concerning GMAW Safety."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat step 9.

☐ 11. **Check** With instructor for any additional assignments to be completed.

☐ 12. **Do** Additional assignments listed below.

____

____

____

Learning Activities Sheet

☐ 13. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 14. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to define the gas metal arc welding process and solve problems related to GMAW safety. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to GMAW orientation and safety with their definitions.
2. Complete statements concerning the advantages of the GMAW process.
3. Select true statements concerning the limitations of the GMAW process.
4. Complete statements concerning principles of GMAW.
5. Solve problems concerning GMAW applications.
6. Select true statements concerning benefits from learning GMAW.
7. Select true statements concerning electrical safety requirements for GMAW.
8. Select true statements concerning guidelines for duty cycle safety.
9. Solve problems concerning rules for handling cables and gas and coolant hoses.
10. Complete statements concerning rules for handling hollow castings or containers.
11. Select true statements concerning hazards associated with arc rays.
12. Complete statements concerning types of welding hoods and their characteristics.
13. Complete statements concerning guidelines for selecting a safe lens shade for GMAW.
14. Select true statements concerning protective clothing required for GMAW.
15. Complete statements concerning environmental safety requirements.
16. Select true statements concerning safety guidelines for working with electrode wire.

*17. Solve problems concerning GMAW safety. (Assignment Sheet 1)

*The Assignment Sheet is located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Automatic**—A GMAW process in which the welding current is continuous in a programmed application; the workpiece travels under a welding head or the welding head travels along the workpiece

b. **Consumable**—That which can be used up; a way of defining electrode wires used in GMAW

c. **Contaminants**—Elements in air, impurities in shielding gases, or chemical reactions between base metals and electrodes

d. **Deposition**—The weight of filler metal placed onto or into a weld in a given period of time

e. **Gas Metal Arc Welding (GMAW)**—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding comes entirely from an externally supplied gas

f. **Inert**—An element that has no active properties

g. **Metal Inert Gas (MIG)**—A nonstandard term still used in reference to GMAW

h. **NEMA**—National Electrical Manufacturer's Association

i. **Oxygen displacement**—A reduction of oxygen in the breathing zone around a welding activity caused by any arc or flame

j. **Reactive**—An element or gas that has properties which will actively combine with other elements present in a base metal or a filler electrode at high temperature

k. **Semiautomatic**—A GMAW process in which the welding current is completed as an operator squeezes a gun trigger

l. **Shielding gases**—Inert gases such as argon or helium, or reactive gases such as CO_2, which are directed under pressure into a weld zone to protect it from atmospheric contamination

m. **Toxic hazards**—Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

Objective 2

Advantages of the GMAW process

a. Beginners can be more quickly trained to weld with the GMAW process than with any other welding process.

b. Because GMAW better controls heat in the weld zone, it reduces distortion in base metals.

c. Because the GMAW arc is always visible to the operator, better welds are possible.

d. GMAW gives a high deposition efficiency with up to 98% of the welding wire deposited in the joint.

e. GMAW is adaptable to both ferrous and nonferrous metals in all thicknesses through modification of electrode wire and shielding gas selections.

f. GMAW is adaptable to either automatic or semiautomatic operation.

g. GMAW reduces welding costs because it usually requires no cleanup.

Objective 3

Limitations of the GMAW process

a. GMAW will not function in a windy environment.

b. GMAW requires careful setting of electrical components.

Objective 4

Principles of GMAW

a. The GMAW process usually operates on DCEP (DCRP).

Note: Direct Current Electrode Positive (DCEP) is the same as Direct Current Reverse Polarity (DCRP).

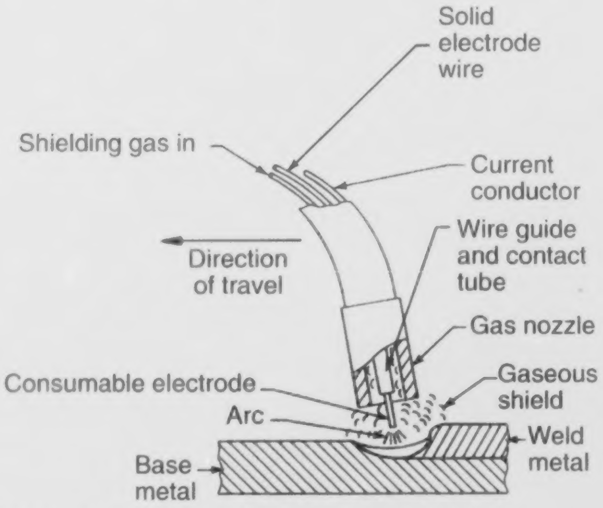
b. The GMAW process is controlled by arc amperage and voltage.

c. Arc amperage in the weld zone is controlled by feeding a bare electrode wire through a wire feeder and cable assembly at a preset feed speed which is calibrated in inches-per-minute.

d. Voltage is controlled by a dial on the welding machine.

e. As the arc is struck, a shielding gas is forced around the electrode wire and the weld zone to stabilize the arc and protect the molten filler metal and base metal from contaminants.

Figure 1


Solid electrode wire
Shielding gas in
Current conductor
Direction of travel
Wire guide and contact tube
Gas nozzle
Consumable electrode
Gaseous shield
Arc
Weld metal
Base metal

Courtesy of Lincoln Electric Company.

Objective 5

GMAW applications

a. GMAW is widely used to join all major commercial steels, including carbon, alloy, and stainless, and in production manufacturing of sheet and plate products.

b. GMAW is widely used to join all major nonferrous metals, especially aluminum magnesium, and copper.

c. GMAW is often used where fit-up is not critical because the high deposition rate can bridge gaps that other processes cannot handle.

d. GMAW is widely used where quick electrical adjustments can be made to compensate for different welding applications without changing electrode wire.

Objective 6

Benefits from learning GMAW

a. Working with GMAW is a good way for a student to learn the concept of a consumable electrode, and shielding gases and their uses.

b. The GMAW process introduces students to electrical concepts and electrical controls that other welding processes do not require.

c. GMAW gives students a better idea of what "operator control" really means in a welding process.

d. As students work with GMAW, they will experience better visibility of the arc, electrode, and total weld zone than with other processes.

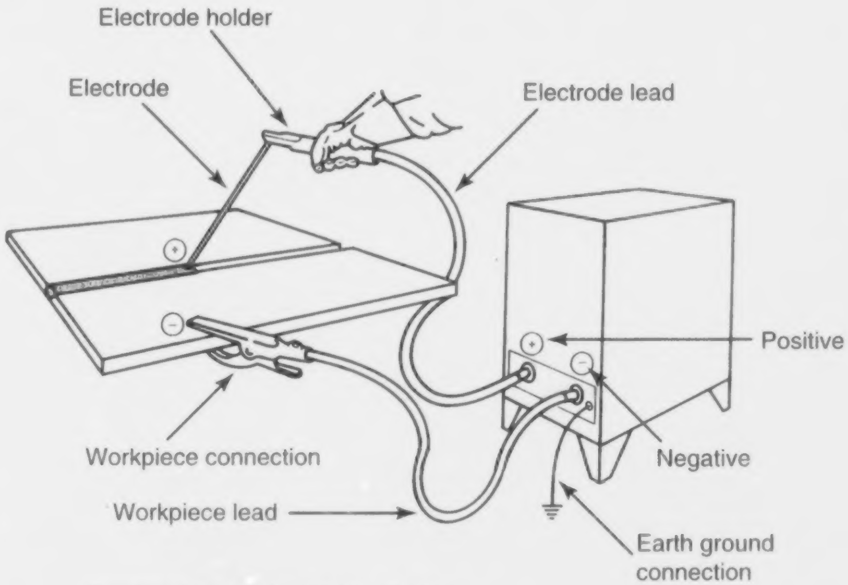
e. Learning GMAW provides a means of employment and additional job-getting skills for industry.

Objective 7

Electrical safety requirements for GMAW

a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.

Figure 2



Courtesy of the American Welding Society.

b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

d. Never dip a GMAW gun in water to cool it.

e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the gun because open-circuit voltages from two machines are increased and can cause a severe shock.

f. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

g. Keep welding cables as close to the work area as possible and do not connect cables to building framework because current can be directed through lifting chains and cables and weaken them.

h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

Objective 8

Guidelines for duty cycle safety

a. Duty cycle is the percent of time during an arbitrary test period that a power source can be operated without overheating.

b. Duty cycle is based on a ten-minute period and the length of time during that period that a machine can be safely operated.

Example: A machine with 20% duty cycle could safely operate 2 minutes out of each 10 minute period.

c. Since duty cycle is rated at the maximum output of a welding machine, the lower the percentage, the more attention is required to time spent actually welding.

d. Use the NEMA classification on the welding machine as a guideline to safe operation:

- Class I—Rated to deliver output at duty cycles of 60, 80, or 100%
- Class II—Rated to deliver output at duty cycles of 30, 40, or 50%
- Class III—Rated to deliver output at duty cycles of 20%

Objective 9

Rules for handling cables and gas and coolant hoses

a. Never drag cables or hoses through dirt or oil, and never pull on a cable to force it over an obstruction.

b. Use only clean, dry rags to clean cables and hoses.

Caution: Never use gasoline or an oily rag on cables and hoses.

c. When not in use, keep cables and hoses coiled free of kinks and properly stored.

d. Never drape a welding cable over any type of gas cylinder, and NEVER strike an arc on a gas cylinder.

e. Never interchange gas and water hoses.

f. Disconnect and remove electrode holders and cables used.

g. Keep cables off metal tables or any grounding surfaces.

h. Make sure water-cooled systems have water turned off when shutting down.

i. Use welding cable covers.

Objective 10

Rules for handling hollow castings or containers

a. Hollow castings or containers should be vented before any heating, cutting, or welding activity.

b. Tanks, drums, and sealed containers should not be heated, cut, or welded until they have been carefully purged of any toxic or flammable materials.

Objective 11

Hazards associated with arc rays

a. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

Note: Wear safety glasses with UV protective side shields in addition to a proper welding helmet with filter plate. The side shields provide needed protection from reflected radiation.

b. Radiation from a welding arc is strong enough to burn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

c. Workstations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

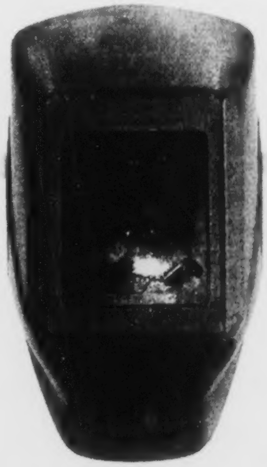
Objective 12

Types of welding hoods and their characteristics

a. Stationary filter lens—This type hood has a fixed lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires.

Note: Always check the clear face lens to make sure it's clean and free of scratches.

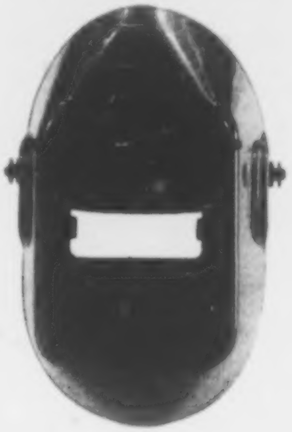
Figure 3



b. Flip-front filter lens—This type hood has a lens housing with a front side that can be flipped up so that it leaves a clear-glass or plastic lens that permits the hood to be worn while chipping.

Note: Always check the clear face lens to make sure it's clean and free of scratches.

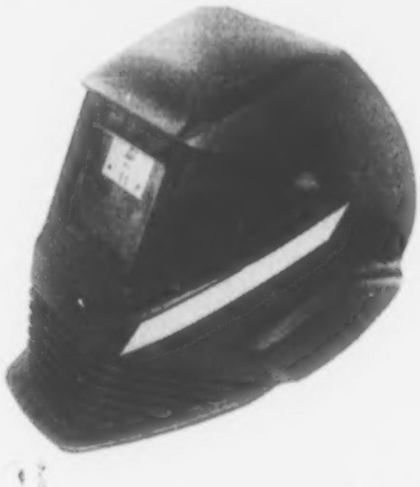
Figure 4



c. Auto darkening lens—This type of lens is used with a helmet specifically designed for auto darkening lenses.

- Contains sensors that automatically change the shade lens from clear to dark in a fraction of a second when you start to weld
- Gradually changes from dark to clear when you stop welding
- Can be manually adjusted to a variety of shades

Figure 5



Objective 13

Guidelines for selecting a safe lens shade for GMAW

a. Safe lens selection for GMAW depends on electrode size, which in turn dictates amperage or current setting.

b. The rule of thumb for GMAW lens selection is that the higher the amperage, the higher the lens shade number required.

c. Operator comfort is also an important part of lens shade selection, and some welders can operate safely with a minimum protective shade while others may require a darker shade for comfort and safety.

Arc Current	Minimum Protective Shade
Less than 60	7
60–160	10
160–250	10
250–500	10

Note: As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade that gives sufficient view of the weld zone without going below the minimum.

d. In all cases, never use the GMAW process with anything less than a #7 lens shade.

e. When you remove your welding hood and see white spots or blotches as after images, switch to a shade at least one number darker, or check the seal on your lens.

Objective 14

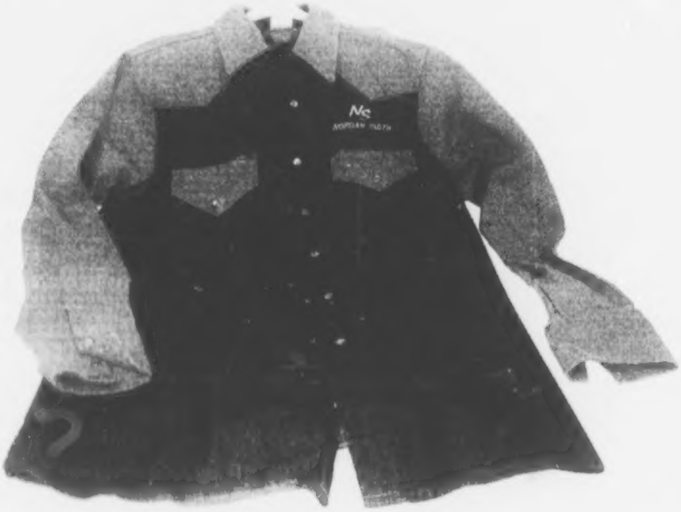
Protective clothing required for GMAW welding

Caution: Always avoid clothing with tears, snags, rips, or worn spots. They are easily ignited by sparks.

a. Shirts

- Should be heavy, long-sleeve shirts with pocket flaps
- Keep collar and sleeves buttoned to keep out sparks, and remove pockets from front of shirt or tape them shut if they don't have pocket flaps

Figure 6



b. Pants

- Should not have cuffs
- Should be long enough to come down over shoe/boot tops

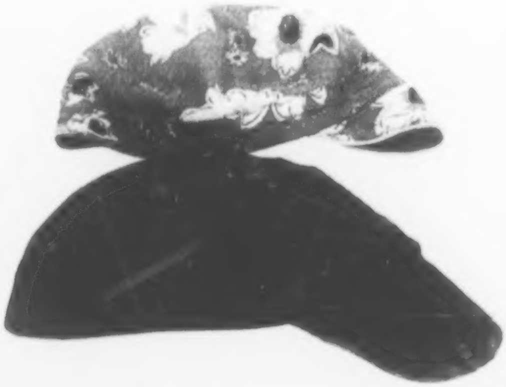
Caution: Clothes made of polyester and other synthetics catch fire easily so it's better to wear wool or heavily-starched cottons.

c. Welding caps

- Should be worn to protect hair from sparks and spatter
- Has a flexible bill that can be slipped around to cover either ear and keep sparks or metal spatter out of the ear opening

Caution: Some hair sprays are highly flammable and can be ignited by sparks, and any kind of plastic hair cap or covering is dangerous in the welding area.

Figure 7



d. Boots

- Should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter
- Should be steel toed

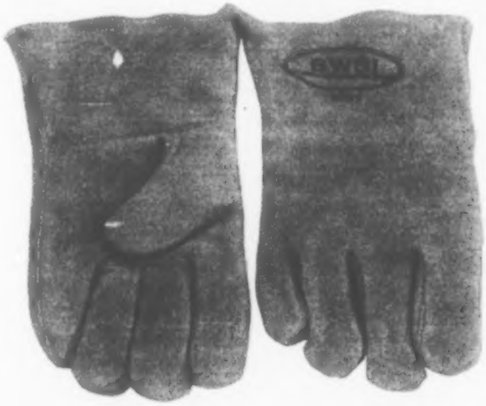
  Note: Steel-toed boots are required in many states.

- If low-topped shoes are worn, the ankles should be protected by fire-resistant leggings.

  Note: Never wear sneakers, tennis shoes, sandals, or loafer-type shoes when welding.

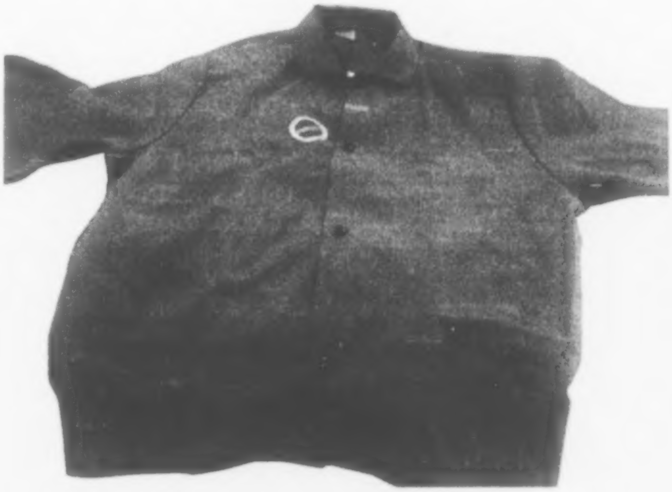
e. Gloves—Heavy leather gloves with gauntlets are required for all welding and cutting activities. Gauntlets may be short or extend to the shoulder.

Figure 8



f. Jackets and aprons—Leather jackets and aprons should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard.

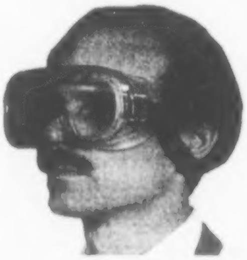
Figure 9



g. Safety glasses

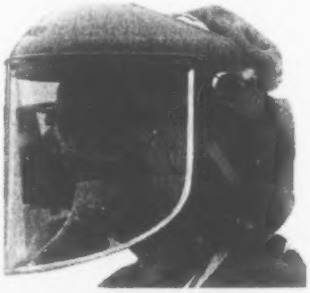
- Should have nonmetal frames
- Should have impact-resistant lenses with side shields to protect from flying objects
- Should be worn at all times in the shop area

Figure 10



h. Face shield—Wear a clear-plastic type of face shield to provide good visibility when grinding or sanding base metals for GMAW.

Figure 11



Objective 15

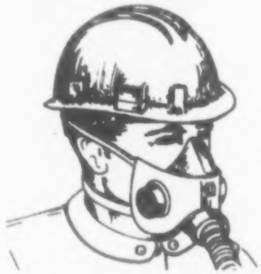
Environmental safety requirements

a. Ventilation—Many welding activities produce toxic fumes and vapors that are hazardous to breathe, and every workstation should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

Caution: Always position your head to the side of rising fumes.

b. Respirators—In confined areas where the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter-type mask that cannot compensate for oxygen displacement.

Figure 12



> **Caution:** Argon is much heavier than air and will quickly displace oxygen, so be especially careful using the GMAW process in confined areas, even though they appear to have adequate ventilation.

c. Noise—This is a workplace hazard frequently overlooked, but earplugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are continuous.

d. Lighting—Lighting in a work area or at a workstation should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to eye fatigue, irritation, and poor work.

Objective 16

Safety guidelines for working with electrode wire

a. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye.

b. Make sure you have the correct spool or coil before loading and cutting tie wires.

c. Hold the free end of electrode wire firmly to avoid backlash during the reloading procedure because failure to do so could ruin an entire spool or coil.

d. Position coils close to the reel before lifting, and lift with your legs, not your back, because standard coils weigh 30–44 pounds.

e. Never look into a gun while you are feeding wire through it, and never point the gun at anyone else.

f. Never place your finger or hand over the contact tip to see if the wire is feeding properly.

Unit 2 GMAW Equipment, Applications, and Techniques

Unit Contents

Student Components

Student Page

Learning Activities Sheet 2–3

Objective Sheet 2–11

Information Sheet 2–17

Student Supplements

1—Recommended Electrodes for GMAW 2–43
2—Surface Tension Transfer Process 2–45
3—Inverter Technology 2–47
4—Recommended Initial Settings for STT 2–49
5—Recommended GMAW Shielding Gases 2–53
6—Gas Metal Arc Welding Conditions 2–57
7—GMAW/Microprocessor Troubleshooting 2–59

*Job Sheets

1—Set Up Wire on a GMAW Wire Feeder 3
2—Set Up a Flow Meter and Regulator for a GMAW Shielding Gas 7
3—Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel 9
4—Prepare Mild Steel for GMAW 11
5—Use Short-Circuit Transfer to Lay Stringer Beads and Build a Pad on Mild Steel in the Flat Position 13
6—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 17
7—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 21
8—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 25
9—Perform a Guided-Bend Test on a Welded V-Groove Butt Joint 29
10—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 35
11—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 39
12—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 43
13—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position 47
14—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position 51
15—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position 55
16—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position 61
17—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position 65

Unit Contents

18—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position . 69
19—Set Up GMAW Equipment for Spray Transfer on Mild Steel . . . 75
20—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 79
21—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 83
22—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 87
23—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 91
24—Use Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 95
25—Set Up GMAW Equipment for Spray Transfer on Aluminum . . . 99
26—Prepare Aluminum for GMAW 103
27—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position 105
28—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position 109
29—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position 113
30—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position 117
31—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Up Position 121
32—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position 125
33—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position 129
34—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position 133
35—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position 137
36—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position 141
37—Set Up GMAW-P Equipment for Pulsed-Spray Transfer on Mild Steel 145
38—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 147
39—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 151
40—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position . . . 155
41—Set Up STT Equipment for Surface Tension Transfer on Mild Steel 159
42—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 161
43—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 165
44—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position . . . 169

*Job Sheets are located in the Student Workbook.

171

Prerequisites:
Unit 1

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 5, and Student Supplement 1.

Optional

☐ 4. **View** Videotape entitled *Gas Metal Arc Welding.*

☐ 5. **Study** Information Sheet, Objective 6, and Student Supplements 2, 3, and 4.

☐ 6. **Study** Information Sheet, Objectives 7 through 15.

☐ 7. **Observe** Demonstration of procedures to be used in completing Job Sheet 1.

☐ 8. **Do** Job Sheet 1, "Set Up Wire on a GMAW Wire Feeder."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat steps 6, 7, and 8.

☐ 10. **Study** Information Sheet, Objectives 16 through 20.

Optional

☐ 11. **Research** Online resources regarding GMAW machines. Visit www.lincolnelectric.com as one of your sources.

☐ 12. **Study** Information Sheet, Objective 21, and Student Supplement 5.

☐ 13. **Study** Information Sheet, Objectives 22 through 25, and Student Supplement 6.

Learning Activities Sheet

☐ 14.	**Study**	Information Sheet, Objectives 26 through 33, and Student Supplement 7.
☐ 15.	**Observe**	Demonstration(s) of procedures to be used in completing Job Sheet 2, 3, and 4.
☐ 16.	**Do**	**Job Sheet 2**, "Set Up a Flow Meter and Regulator for a GMAW Shielding Gas," **Job Sheet 3**, "Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel," and **Job Sheet 4**, "Prepare Mild Steel for GMAW."
☐ 17.	**Stop**	After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 2, 3, and 4, continue to step 18.
☐ 18.	**Observe**	Demonstration of procedures to be used in completing Job Sheet 5.
☐ 19.	**Do**	Job Sheet 5, "Use Short-Circuit Transfer to Lay Stringer Beads and Build a Pad on Mild Steel in the Flat Position."
☐ 20.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat steps 18 and 19.
☐ 21.	**Observe**	Demonstration(s) of procedures to be used in completing Job Sheet 6 and Job Sheet 7.
☐ 22.	**Do**	**Job Sheet 6**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position" and **Job Sheet 7**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position."
☐ 23.	**Stop**	After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 6 and 7, continue to step 24.
☐ 24.	**Observe**	Demonstration(s) of procedures to be used in completing Job Sheet 8 and Job Sheet 9.

☐ 25. **Do** — **Job Sheet 8**, "Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position" and **Job Sheet 9**, "Perform a Guided-Bend Test on a Welded V-Groove Butt Joint."

☐ 26. **Stop** — After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 8 and 9, continue to step 27.

☐ 27. **Observe** — Demonstration(s) of procedures to be used in completing Job Sheets 10 through 18.

☐ 28. **Do** — **Job Sheet 10**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position," **Job Sheet 11**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position," **Job Sheet 12**, "Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position," **Job Sheet 13**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position," **Job Sheet 14**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position," **Job Sheet 15**, "Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position," **Job Sheet 16**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position," **Job Sheet 17**, "Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position," and **Job Sheet 18**, "Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position."

☐ 29. **Stop** — After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 10 through 18, continue to step 30.

☐ 30. **Observe** — Demonstration of procedures to be used in completing Job Sheet 19.

☐ 31. **Do** — Job Sheet 19, "Set Up GMAW Equipment for Spray Transfer on Mild Steel."

☐ 32. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 33. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 19 and repeat steps 30 and 31.

☐ 33. **Observe** Demonstration(s) of procedures to be used in completing Job Sheets 20 through 24.

☐ 34. **Do** **Job Sheet 20**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position," **Job Sheet 21**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position," **Job Sheet 22**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position," **Job Sheet 23**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position," and **Job Sheet 24**, "Use Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position."

☐ 35. **Stop** After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 20 through 24, continue to step 36.

☐ 36. **Observe** Demonstration(s) of procedures to be used in completing Job Sheet 25 and Job Sheet 26.

☐ 37. **Do** **Job Sheet 25**, "Set Up GMAW Equipment for Spray Transfer on Aluminum" and **Job Sheet 26**, "Prepare Aluminum for GMAW."

☐ 38. **Stop** After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 25 and 26, continue to step 39.

☐ 39. **Observe** Demonstration(s) of procedures to be used in completing Job Sheets 27 through 36.

☐ 40. **Do** **Job Sheet 27**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position," **Job Sheet 28**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position," **Job Sheet 29**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position," **Job Sheet 30**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position," **Job Sheet 31**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel on Aluminum in the Vertical Up Position, **Job Sheet 32**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position," **Job Sheet 33**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position," **Job Sheet 34**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position," **Job Sheet 35**, "Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position," and **Job Sheet 36**, "Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position."

☐ 41. **Stop** After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 27 through 36, continue to step 42.

☐ 42. **Observe** Demonstration of procedures to be used in completing Job Sheet 37.

☐ 43. **Do** Job Sheet 37, "Set Up GMAW-P Equipment for Pulsed-Spray Transfer on Mild Steel."

☐ 44. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 45. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 37 and repeat steps 42 and 43.

☐ 45. **Observe** Demonstration(s) of procedures to be used in completing Job Sheets 38 through 40.

☐ 46.	**Do**	**Job Sheet 38**, "Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position," **Job Sheet 39**, "Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position," and **Job Sheet 40**, "Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position."
☐ 47.	**Stop**	After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 38 through 40, continue to step 48.
☐ 48.	**Observe**	Demonstration of procedures to be used in completing Job Sheet 41.
☐ 49.	**Do**	Job Sheet 41, "Set Up STT Equipment for Surface Tension Transfer on Mild Steel."
☐ 50.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 51. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 41 and repeat steps 48 and 49.
☐ 51.	**Read**	Student Supplement 4, "Recommended Initial Settings for STT." Refer to this student supplement for initial settings before completing Job Sheets 42, 43, and 44.
☐ 52.	**Observe**	Demonstration(s) of procedures to be used in completing Job Sheets 42, 43, and 44.
☐ 53.	**Do**	**Job Sheet 42**, "Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position," **Job Sheet 43**, "Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position," and **Job Sheet 44**, "Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position."

☐ 54. **Stop** After completing each job sheet, have your instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that job sheet, and redo the job sheet. After satisfactorily completing Job Sheets 42, 43, and 44, continue to step 55.

☐ 55. **Check** With instructor for any additional assignments to be completed.

☐ 56. **Do** Additional assignments listed below.

____

____

____

☐ 57. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 58. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

*Permission to duplicate this form is granted.

Unit 2 GMAW Equipment, Applications, and Techniques

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up equipment for gas metal arc welding, and weld lap joints, V-groove joints, and T-joints on ferrous and nonferrous metals in all positions. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to GMAW equipment, applications, and techniques with their definitions.
2. Complete statements concerning characteristics of short-circuit transfer.
3. Complete statements concerning characteristics of globular transfer.
4. Complete statements concerning characteristics of spray transfer.
5. Complete statements concerning characteristics of pulsed spray transfer.
6. Complete statements concerning characteristics of surface tension transfer.
7. Match GMAW machine controls with their functions.
8. Match GMAW electrical controls with their functions.
9. Match wire feeder controls with their functions.
10. Solve problems concerning roll adjustment requirements for wire feeders.
11. Select true statements concerning preventive maintenance requirements for wire feeders.
12. Select true statements concerning AWS classifications for electrode wires.
13. Match basic short-circuit electrode wires with their characteristics.
14. Solve problems concerning rules of thumb for GMAW, STT, and GMAW-P electrode wire selection.
15. Select true statements concerning guidelines for storing spools and coils of electrode wire.
16. Complete statements concerning types of GMAW guns and their characteristics.

17. Match parts of a GMAW gun tip with their functions.
18. Complete statements concerning steps in assembling contact tips, gas diffusers, nozzles, and insulators.
19. Solve problems concerning maintenance requirements for GMAW guns.
20. Select true statements concerning electrode extension and its function in GMAW.
21. Complete statements concerning GMAW shielding gases and their applications.
22. Differentiate between GMAW welding techniques and their characteristics.
23. Solve problems concerning techniques for properly ending a GMAW weld.
24. Select true statements concerning techniques for position welding with GMAW.
25. Complete statements concerning conditions that require special attention with GMAW.
26. Complete a chart of possible causes and corrective actions for undercutting.
27. Complete a chart of possible causes and corrective actions for porosity.
28. Complete a chart of possible causes and corrective actions for incomplete fusion.
29. Complete a chart of possible causes and corrective actions for incomplete joint penetration.
30. Complete a chart of possible causes and corrective actions for excessive melt-through.
31. Complete statements concerning flow meters and their use in GMAW.
32. Select true statements concerning flow rates for GMAW shielding gases.
33. Solve problems concerning guidelines for troubleshooting GMAW problems.

*34. Set up wire on a GMAW wire feeder. (Job Sheet 1)

*35. Set up a flow meter and regulator for a GMAW shielding gas. (Job Sheet 2)

*36. Set up GMAW equipment for short-circuit transfer on mild steel. (Job Sheet 3)

*37. Prepare mild steel for GMAW. (Job Sheet 4)

*38. Use short-circuit transfer to lay stringer beads and build a pad on mild steel in the flat position. (Job Sheet 5)

*39. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position. (Job Sheet 6)

*40. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position. (Job Sheet 7)

*41. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 8)

*42. Perform a guided-bend test on a welded V-groove butt joint. (Job Sheet 9)

*43. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (Job Sheet 10)

*44. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (Job Sheet 11)

*45. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position. (Job Sheet 12)

*46. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position. (Job Sheet 13)

*47. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the vertical position. (Job Sheet 14)

*48. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position. (Job Sheet 15)

*49. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position. (Job Sheet 16)

*50. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position. (Job Sheet 17)

*51. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position. (Job Sheet 18)

*52. Set up GMAW equipment for spray transfer on mild steel. (Job Sheet 19)

*53. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position. (Job Sheet 20)

*54. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position. (Job Sheet 21)

*55. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (Job Sheet 22)

Objective Sheet

*56. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (Job Sheet 23)

*57. Use spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 24)

*58. Set up GMAW equipment for spray transfer on aluminum. (Job Sheet 25)

*59. Prepare aluminum for GMAW. (Job Sheet 26)

*60. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position. (Job Sheet 27)

*61. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position. (Job Sheet 28)

*62. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position. (Job Sheet 29)

*63. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position. (Job Sheet 30)

*64. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position. (Job Sheet 31)

*65. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position. (Job Sheet 32)

*66. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position. (Job Sheet 33)

*67. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position. (Job Sheet 34)

*68. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position. (Job Sheet 35)

*69. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position. (Job Sheet 36)

*70. Set up GMAW-P equipment for pulsed-spray transfer on mild steel. (Job Sheet 37)

*71. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 38)

*72. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position. (Job Sheet 39)

*73. Use pulsed-spray transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position. (Job Sheet 40)

*74. Set up STT equipment for surface tension transfer on mild steel. (Job Sheet 41)

*75. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 42)

*76. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position. (Job Sheet 43)

*77. Use surface tension transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position. (Job Sheet 44)

*Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Electrode extension**—The distance between the end of the contact tube and the end of the electrode

Note: Electrode extension is also called *electrode stickout* or *wire stickout*.

b. **Globular transfer**—A GMAW application in which average currents slightly higher than those used with short-circuit transfer are used to form a droplet that goes onto a base metal as a result of short-circuiting or gravity

c. **Inductance**—The rate of rise of current as opposed to the final amount of current available; used in short-circuit transfer to increase or decrease the number of short-circuit metal transfers per second

d. **Inverter technology**—Inverter power supplies that use high speed microprocessors are capable of switching from peak to background current at over 40 Khz. This high speed switching controls metal transfer while sampling the voltage to control the arc length.

Note: STT is an example of inverter technology.

e. **Metal core**—A GMAW process similar to FCAW except that a metal powder is located inside the wire instead of flux

f. **Microprocessor**—A computer processor contained on an integrated circuit chip that has memory and associated circuits

g. **Out-of-position welding**—Any welding position other than flat

h. **Pulsed spray transfer (GMAW-P)**—A variation of spray transfer where the power source quickly pulses between a peak and background current for a fixed period of time

i. **Short-circuit transfer**—A GMAW application in which low currents, low voltages, and small diameter wires are used to weld in all positions on thin to heavy metals

j. **Slope**—The slant of the volts versus amp curve, or the volts change per 100 amps

k. **Slope control**—A power supply control that regulates the amount of pinch force available on welding wire and controls spatter in short-circuit transfer

l. **Spray transfer**—A GMAW application in which high currents, high voltages, and larger diameter wires are used to weld thicker metals mostly in the flat and horizontal positions

m. **Surface tension transfer™ (STT®)**—A current controlled short circuiting transfer process; welding current is based on the instantaneous requirements of the arc; wire feed speed and current are independent of one another

n. **Travel angle**—The relationship of the electrode axis with respect to the direction of travel

o. **Travel speed**—The linear rate at which the arc is moved along the weld joint

p. **Work angle**—The angle between the electrode axis and the adjacent work surface

Objective 2

Characteristics of short-circuit transfer

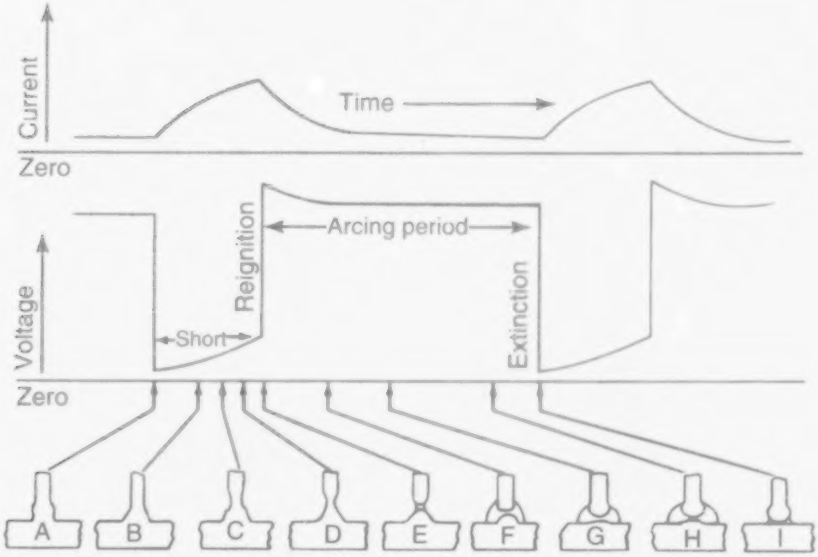
a. Short-circuit transfer with GMAW is accomplished with a low range of welding currents, small diameter wires, direct current, and electrode positive (DCEP).

b. The small, fast-freezing weld pool created with short-circuit transfer makes it suited for joining thin sections, for out-of-position welding, and for bridging large root openings.

c. In short-circuit transfer, no metal is transferred across the arc gap, and the open circuit voltage of the power source must be so low that the drop of molten metal at the wire tip cannot transfer until it touches the base metal.

Example: In the following illustration, A, B, C, and D show how the current increases as the arc touches the weld metal. The molten metal at the wire tip pinches off at D and F, initiating an arc as shown in E and F. When the arc is established, the wire melts at the tip, H, and the wire feeds forward to start the next transfer.

Figure 1



Courtesy of the American Welding Society.

d. CO_2 is used as a shielding gas with short-circuit transfer because it promotes deep penetration, but mixtures of CO_2 and argon are used to control spatter.

185

Objective 3

Characteristics of globular transfer

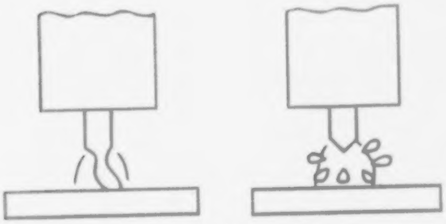
a. Globular transfer with GMAW is characterized by a very erratic globular pattern with a droplet size greater than that of the electrode (DCEP).

b. Globular transfer is accomplished with average currents only slightly higher than those used with short-circuit transfer.

c. One type of globular transfer occurs when the molten drop grows until it detaches by short-circuiting.

Note: The action is similar to short-circuit transfer, but the molten drop comes in contact with the base metal, the wire tip does not.

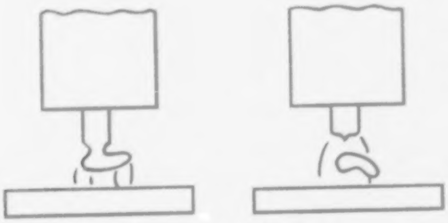
Figure 2



Courtesy of the American Welding Society.

d. Another type of globular transfer occurs when gravity alone causes the molten drop to fall onto the weld pool.

Figure 3



Courtesy of the American Welding Society.

e. CO_2 is commonly used for globular transfer, especially with mild steels.

Information Sheet

Objective 4

Characteristics of spray transfer

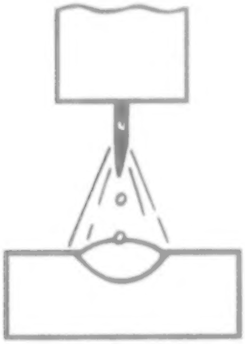
a. Spray transfer with GMAW is accomplished with the use of direct current electrode positive (DCEP) limited to flat and horizontal positions.

b. Spray transfer must have an argon-rich shielding gas mixture containing at least 80% argon.

c. The metal transfer across the arc changes from globular to spray as current increases above a certain value known as the transition current.

d. Because the individual drops are equal to or smaller than the diameter of the electrode, and are nearly constantly sprayed through the arc plasma. spatter is virtually eliminated.

Figure 4



Courtesy of the American Welding Society.

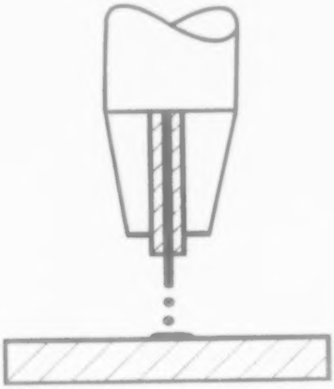
e. The arc is very smooth and stable, penetration is deeper than SMAW but less than globular transfer mode of GMAW.

Objective 5

Characteristics of pulsed spray transfer

a. Pulsed spray transfer is characterized by molten drops formed by the low current arc, pinched off and propelled to the weld pool by the high current pulse.

Figure 5



b. Lower average current of the pulsing mode allows all position welding and welding of thin materials.

c. Reduction of cold lapping is due to the use of a higher energy level than normally seen with short-circuit.

d. Pulsed spray with GMAW is accomplished with the use of direct current and an electrode positive (DCEP).

Objective 6

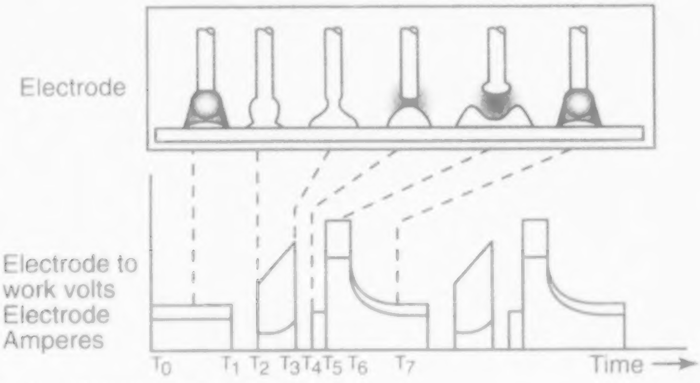
Characteristics of surface tension transfer (STT)

a. Surface tension transfer is characterized by wire feed speed and current being totally independent of each other.

b. The welding current is based on the instantaneous requirements of the arc.

c. The current is always controlled in a logical manner based on what portion of the shorting cycle is to be performed.

Figure 6



Courtesy of Lincoln Electric Company.

d. Surface tension transfer with GMAW is accomplished with the use of direct current and an electrode positive (DCEP).

e. STT is an example of inverter technology.

Note: For more information on inverter technology, refer to Student Supplement 3.

Objective 7

GMAW machine controls and their functions

a. **Power supply**—A rectifier-type DC welding machine which controls voltage used in the basic GMAW processes

b. **Inverter power supply**—Utilizes solid-state components to change the incoming 60 Hz power to a higher frequency, 18 to 100 kHz

c. **Wire feeder**—A roller device used to vary and control the speed at which wire is fed to the welding arc in relation to amperage and wire feed speed

d. **Gun and cable assembly**—Cable transports power to trigger-operated gun through which the wire, shielding gas, and coolant pass

e. **Gun**—Trigger-operated on-off device through which wire, shielding gas, and coolant are controlled at the weld zone

f. **Flowmeter regulator**—Used to reduce high-pressure cylinder gas to low pressure gas so its flow rate can be controlled to the welding gun as measured in CFH (cubic feet per hour)

g. **Coolant solenoid**—An on-off switch or valve that activates coolant flow in water-cooled GMAW systems

Objective 8

GMAW electrical controls and their functions

Note: Microprocessor-based machines are available that have various functions.

a. **On-off switch**—Used to start or stop the electrical power to a machine

b. **Voltage range selector**—Used to control wide-range voltage selection such as 12–28 volts for low range and 20–35 volts for high range

c. **Fine voltage control**—Used to fine tune the voltage selection within the wide-range setting

d. **Power supply voltmeter**—Used to calibrate and check voltage adjustments

e. **Power supply ammeter**—Used to calibrate and check amperage adjustments

f. **Slope**—Used to add or decrease the rate of resistance change in a welding machine for pinch control which minimizes spatter

g. **Polarity switch**—Used to change polarity from DCEP to DCEN so meters for amps and volts can be properly read

h. **Contactor**—Used to complete circuit through wire feed and function as an on-off device for wire feed

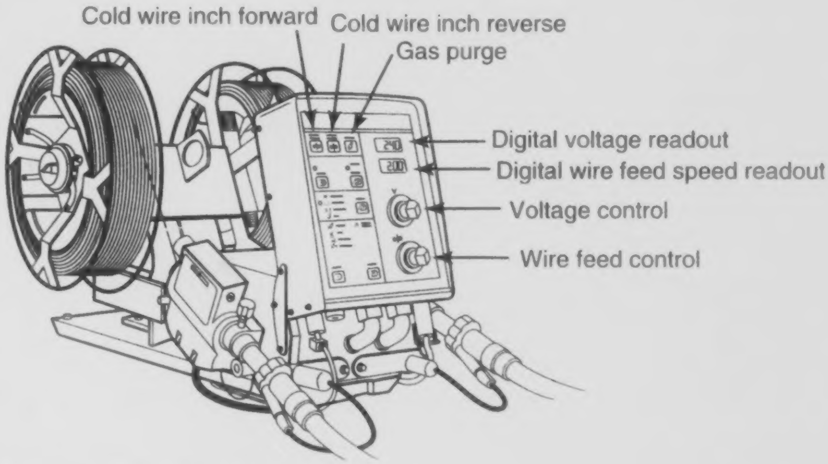
i. **Inductance**—Used to control arc-on time in short-circuit welding to control puddle fluidity and produce a flatter, smoother weld bead

Objective 9

Wire feeder controls and their functions

Note: Some wire feeders are controlled by microprocessors.

Figure 7



Courtesy of Lincoln Electric Company.

a. **On-off switch**—A switch that controls power input into wire feed mechanism

b. **Wire feed control**—A control that functions as a dual control to regulate wire feed rate in inches-per-minute in relation to amperage

c. **Contactor dropout**—A device that increases or decreases burn back on electrode extension

d. **Spot weld function**—An on-off device that routes current through a timer which provides a specific time for each trigger activation regardless of how long or briefly the trigger is held

e. **Gas purge**—A device to permit purging of a shielding gas through the gun without having wire feed at the same time

f. **Wire-inch switch**—A switch used to advance wire for setting up purposes and does not activate other components

g. **Remote unit**—A control that makes voltage adjustment possible in situations where welding activity is far enough away from the welding machine to make it impractical to stop welding in order to make adjustments at the machine

   Note: Remote units are self-contained, usually have long extension cords, and some guns have remote adjustment capabilities built in.

h. **Cold wire inch forward**—A handy device that permits fast loading of wire into gun

i. **Cold wire inch reverse**—A handy device that permits excess wire spooled off during loading to be rewound and used, as opposed to wasted

j. **Pulse control**—Wire feeders with pulse capability that may have one or more switches allowing the unit to be adjusted manually on older machines or electronically on newer machines

k. **Voltage control**—A device that controls arc voltage

Objective 10

Roll adjustment requirements for wire feeders

a. When the tension on wire feeder rolls is too tight, the rolls may flatten or shave the wire.

b. A flattened wire will usually "bird nest" at the feed roll and not feed through the cable.

c. A shaved wire creates small flakes of wire around the feed rolls and could create an electrical hazard or make the wire "bird nest."

d. Wire should not be too tight or too loose.

e. Most wire feeders have drive rolls for different sizes of wire and the proper roller size should be checked so it will properly roll the size wire being used.

f. Inlet and outlet guides should match the wire diameter used.

Objective 11

Preventive maintenance requirements for wire feeders

a. Feed rolls should be checked and cleaned daily.

b. All electrical connections into and out of the feeder should be checked daily and tightened as required.

c. The drag brake needs to be checked before each use to make sure it feeds off smoothly with no free wheeling.

d. All gas hoses and connections should be inspected for leaks before each operation.

Objective 12

AWS classifications for electrode wires

a. AWS classifications for electrode wire use letter and number designations to identify type of electrode and basic composition.

b. As in other classifications, the letter E indicates electrode, and when followed by the letter R, it indicates that the filler metal may be used as an electrode or welding rod.

c. Interior numbers indicate minimum tensile strength in multiples of 1,000 psi.

d. The letter S indicates a bare solid electrode or rod.

e. Final letter-number classifications indicate special chemical compositions of the electrode wire.

Example: With an ER80S-B2 electrode wire, the E indicates an electrode, the R indicates the wire can be used as a welding rod, the 80 indicates a tensile strength of 80,000 psi, the S indicates a solid electrode, and the B2 indicates that the electrode contains a certain amount of Chrome and Molybdenum, which is used for elevated temperatures and corrosive services.

Note: See Student Supplement 1 for additional information about AWS electrode wire classifications.

Objective 13

Basic electrode wires, their characteristics, and AWS classifications

a. **ER70S-2**—This classification produces less fluid weld metal which makes it ideal for welding out-of-position and for welding small diameter pipe. This wire is triple deoxidized with aluminum, titanium, and zirconium.

b. **ER70S-3**—These filler metals are used primarily on single-pass welds, but can be used on multiple-pass welds, especially when welding killed or semi-killed steel. These filler metals will meet the requirements of this specification with either CO_2 or argon-oxygen as a shielding gas.

c. **ER70S-4**—These filler metals contain slightly higher manganese and silicon contents than those of the ER70S-3 classifications, and produce a weld deposit of higher tensile strength.

d. **ER70S-5**—This classification covers filler metals, which contain aluminum in addition to manganese, and silicon as deoxidizers.

e. **ER70S-6**—Filler metals of this classification have the highest combination of manganese and silicon, permitting high current welding with CO_2 gas shielding even in rimmed steels. This filler metal is also usable out of position with short circuiting transfer.

f. **ER70S-7**—These filler metals have substantially greater manganese content than those of the ER70S-3 classifications. This provides slightly better wetting and weld appearance with slightly higher tensile and yield strengths. These filler metals are generally recommended for use with argon-oxygen shielding gas mixtures, but they are usable with argon-CO_2 and CO_2 under the same general conditions as ER70S-3.

g. **ER70S-G**—This classification includes those filler metals which are not included in the preceding classes. The filler metal supplier should be consulted for the characteristics and intended use.

h. **ER80S-B2**—Filler metals of this classification are used to weld 1/2 Cr–1/2 Mo, 1 Cr–1/2 Mo and 1 1/4 Cr–1/2 Mo steels for elevated temperatures and corrosive service.

Objective 14

Rules of thumb for GMAW, STT, and GMAW-P electrode wire selection

a. Filler wires used for short-circuit transfer are usually small diameter wires ranging from .020″ to .045″.

b. Surface tension transfer (STT) can operate with larger diameter wires (.045) as compared to standard wire (.035) because the wire feed speed and current are independent of each other.

c. GMAW-Pulse allows the use of larger diameter wires such as .035 and .045 compared to GMAW short-circuit transfer and out-of-position welding.

d. Filler wires used for globular transfer start at the upper end of the short-circuit transfer sizes, .045″, and the low end of spray transfer wires, .045″.

e. Filler wires used for spray transfer are larger diameter wires ranging from .045″ to .125″.

f. The composition of the electrode wire should match the composition of the base metal on which it will be used.

g. Since the objective of GMAW is to accomplish a high deposition rate at the lowest cost in materials and time, select the largest electrode size that can be used according to the amount of voltage and current available in the machine.

Note: See Student Supplement 1 for GMAW electrode selections and applications.

Objective 15

Guidelines for storing spools and coils of electrode wire

a. Do not unseal or open spools or coils of electrode wire until they are needed for immediate use.

b. Store electrode wires in a clean, dry place.

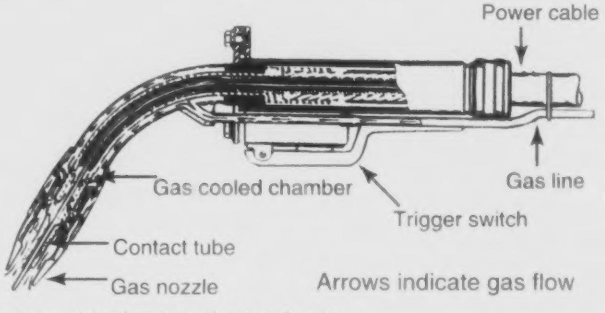
c. Use spools or coils as soon as possible after opening, and cover or reseal remaining wire prior to storage.

Objective 16

Types of GMAW guns and their characteristics

a. **Air cooled**—Used in short-circuit transfer when the welding application requires short distance welds or weld times that are short or intermittent

Figure 8

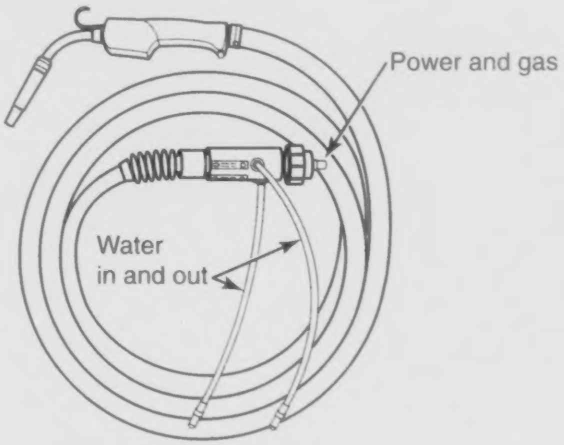


Courtesy of the American Welding Society.

b. **Water cooled**—A gun that must be connected to a water cooler to function properly. Water flows through the gun cables and handle to the end of the gun tube, cooling the gas diffuser and nozzle. In addition to keeping the contact tip cool, the outgoing end of the gun tube is specially designed for maximum heat transfer between the cooling water and the gas nozzle.

Note: The gas nozzle will not overheat, even when operating the gun at 100% duty cycle. This results in cool operation in applications such as spray transfer, pulse welding, and when using argon-blended gas.

Figure 9

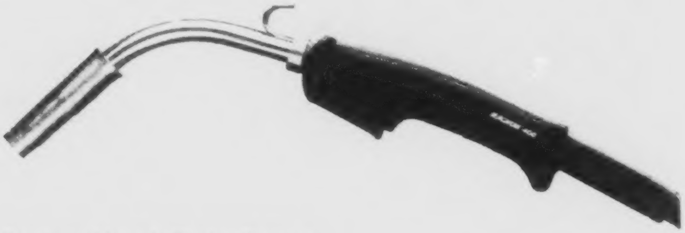


Courtesy of Lincoln Electric Company.

c. **Push**—A gun that has wire pushed directly into it through drive rollers in the wire feed unit

Note: A push gun is typically used to handle heavier diameter hard wires.

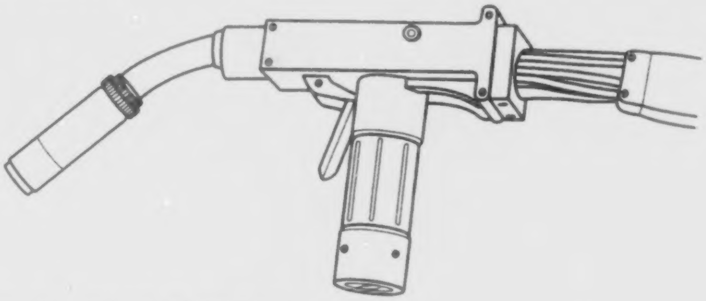
Figure 10



Courtesy of Lincoln Electric Company.

d. **Push-Pull**—A gun that houses a small electric motor that pulls the wire from the reel and feeds it through the contact tips to the weld zone

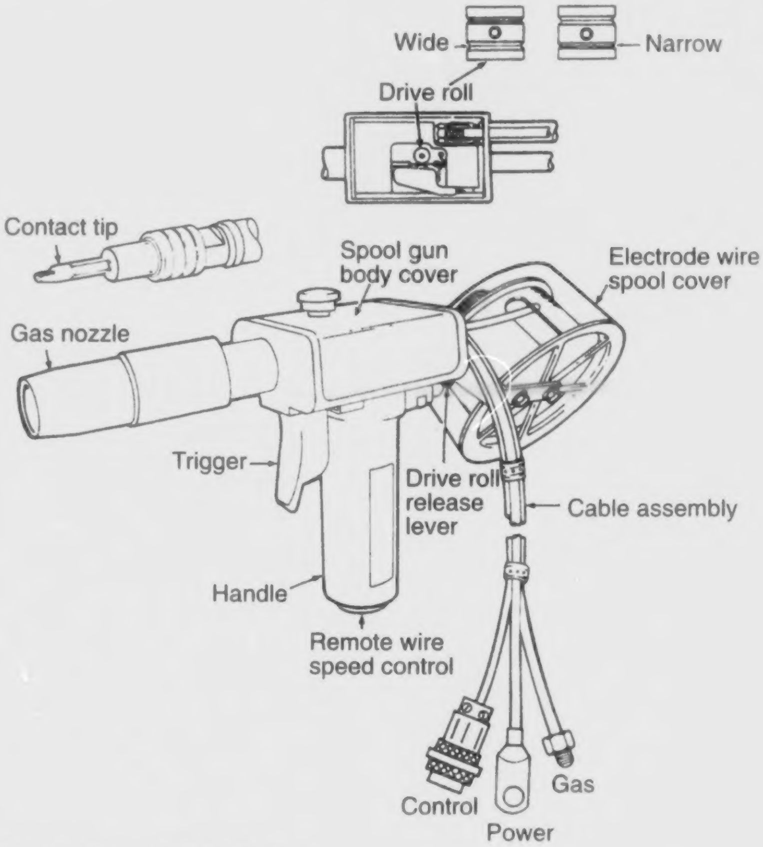
Figure 11



Courtesy of Lincoln Electric Company.

e. **Spool gun**—A gun capable of holding a small spool of wire and feeding it through the contact points, and is used primarily in welding aluminum with wire that is too soft to be pushed or pulled a long distance

Figure 12


Wide
Narrow
Drive roll
Contact tip
Spool gun body cover
Electrode wire spool cover
Gas nozzle
Trigger
Drive roll release lever
Cable assembly
Handle
Remote wire speed control
Control
Power
Gas

Courtesy of Lincoln Electric Company.

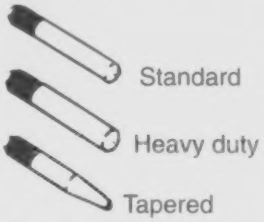
Information Sheet

Objective 17

Parts of a GMAW gun tip and their functions

a. **Contact tip**—A copper device used to guide the wire to the weld, and should be selected according to wire size and type of service, standard, heavy duty, or tapered

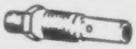
Figure 13


Standard
Heavy duty
Tapered

Courtesy of Tweco®.

b. **Gas diffuser**—A copper device that spreads shielding gas out so that it flows evenly over the electrode wire and the weld zone

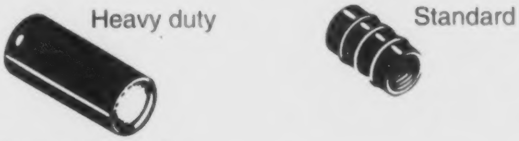
Figure 14



Courtesy of Tweco®.

c. **Nozzle insulator**—Insulates the nozzle from the welding current and holds the nozzle in place

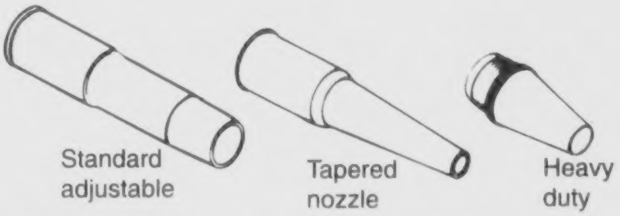
Figure 15


Heavy duty
Standard

Courtesy of Tweco®.

d. **Nozzle**—Directs and holds shielding gas around the weld zone, and may be standard, tapered for tight places, or heavy duty for continuous welding

Figure 16


Standard adjustable
Tapered nozzle
Heavy duty

Courtesy of Tweco®.

Objective 18

Steps in assembling contact tips, gas diffusers, nozzles, and insulators

a. Screw the gas diffuser into the end of the conductor tube assembly with an adjustable wrench, and then tighten the Allen screw that holds the wire-feed conduit.

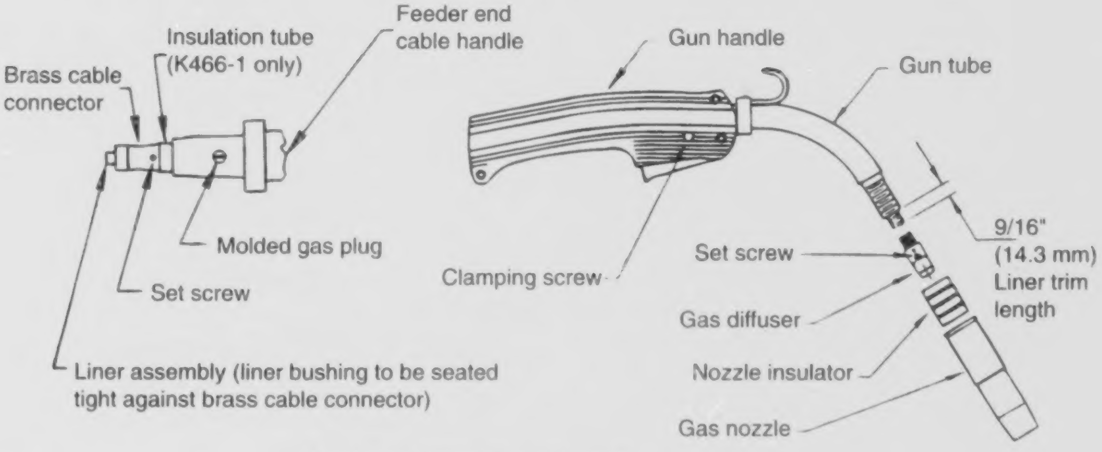
b. Screw the contact tip into the gas diffuser and snug it tight with pliers, but be careful not to damage the contact tip.

c. Screw the nozzle insulator over the diffuser and contact tip and hand tighten.

d. Slide the nozzle over the split-spring rings of the insulator and adjust for electrode extension.

Note: Gun tip components all require careful assembly, and the variety of components is shown in the following illustration.

Figure 17


Feeder end cable handle
Insulation tube (K466-1 only)
Brass cable connector
Gun handle
Gun tube
Molded gas plug
Set screw
Liner assembly (liner bushing to be seated tight against brass cable connector)
Clamping screw
Set screw
Gas diffuser
Nozzle insulator
Gas nozzle
9/16" (14.3 mm) Liner trim length

Courtesy of Lincoln Electric Company

Objective 19

Maintenance requirements for GMAW guns

a. Air cooled guns

- Select contact tips the right size for the wire being used and keep contact tips tight.
- Keep gas diffusers tight on conductor tubes (goose necks).
- Clean nozzle and insulator periodically so the gas flow will not slow down.
- Spray nozzle with anti-spatter gel so it will remain as spatter free as possible.
- Keep cables free of kinks and pinches at all times.

Note: General maintenance requirements for air cooled guns applies to all GMAW guns.

b. Water cooled guns

  - Check daily for leaks.
  - Check water or coolant supply daily to make sure it is adequate for cooling requirements.
  - Check cables for kinks or pinches.

c. Spool guns

  - Check feed roll tension at the beginning of each welding activity to make sure the wire is not being flattened or shaved.
  - Check gas fittings and hoses periodically for leaks.
  - Keep contact tips and gas diffusers tight so resistance will not cause overheating at the gun.

Objective 20

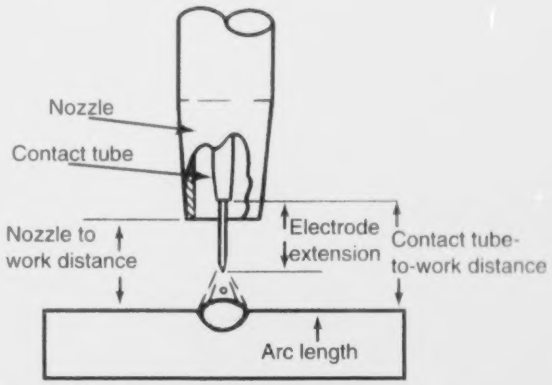
Electrode extension and its function in GMAW

a. Electrode extension gives an operator control of slight but critical adjustments of amperage and voltage needed to correct spatter, penetration, and bead width.

b. Too much electrode extension decreases amperage and slightly increases voltage; this results in more arc which produces spatter and poor penetration.

c. Too little electrode extension increases amperage and slightly decreases voltage; this results in less arc which gives no spatter and good penetration, but it produces a narrow bead with overall poor fusion.

Figure 18



Courtesy of the American Welding Society.

d. Electrode extension for short-circuit transfer and surface tension transfer is 1/4″ to 1/2″.

e. Electrode extension for spray transfer is 3/4″ to 1″.

f. Electrode extension for pulsed spray transfer is 1/2″ to 3/4″.

Objective 21

GMAW shielding gases and their applications

a. Argon is the most frequently used shielding gas for welding nonferrous metals because it produces a clean, narrow bead with deep penetration in both short-circuit and spray transfer.

   Note: Argon is mixed with other gases in order to meet this requirement.

b. Helium is mixed with argon for some aluminum welding in both short-circuit and spray transfer, but helium does not produce the stable arc provided by argon.

c. CO_2 is used primarily on carbon steels because it is far less expensive than other shielding gases, but because CO_2 can produce an unstable arc and spatter, it requires electrode wires with deoxidizing agents.

   Note: A CO_2-argon mixture in varying percentages can be used to alleviate unstable arc problems and spatter.

d. Oxygen is used as a stabilizer in varying percentages with argon for spray transfer on both mild and stainless steels.

Objective 22

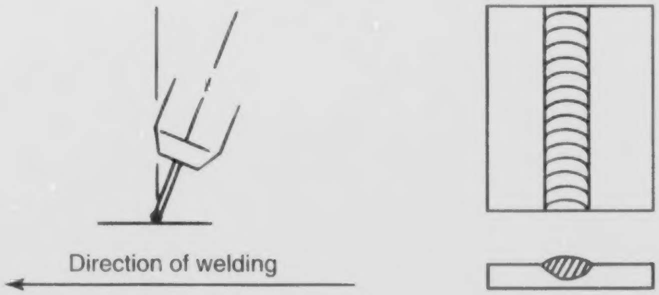
GMAW welding techniques and their characteristics

a. Forehand welding with a lead angle means that the electrode points in the direction of travel.

   Note: Forehand welding is sometimes referred to as the "push" technique.

b. The forehand technique decreases penetration, gives a wider, flatter bead, and is mostly used on thicker metals.

Figure 19



Courtesy of the American Welding Society.

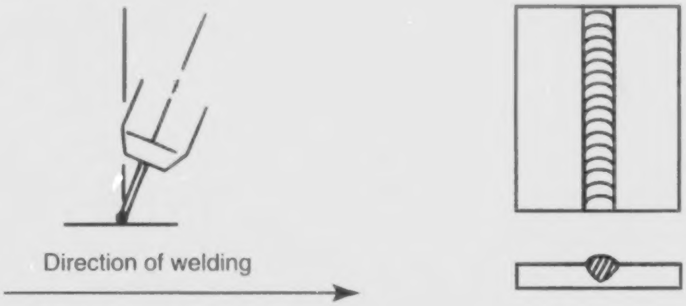
c. Backhand welding with a drag angle means that the electrode points opposite the direction of travel.

   Note: Backhand welding is sometimes referred to as the "drag" or "pull" technique.

d. The backhand welding technique increases penetration, gives a more convex, narrower bead, provides a more stable arc, and leaves less spatter on the workpiece.

e. The backhand technique is mostly used on thinner metals.

Figure 20



Courtesy of the American Welding Society.

Objective 23

Techniques for properly ending a GMAW weld

a. The first step in a common technique for ending a GMAW weld is to release the gun trigger just as the bead reaches the end of the weld.

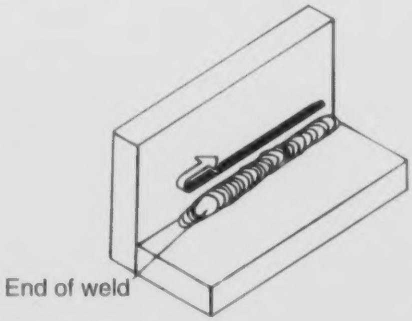
b. Hold the gun in place and hesitate for just a second to keep the molten puddle covered with shielding gas, and then pull the gun away.

Note: The slight hesitation after releasing the trigger is the key to make this technique work because the burn-back control will continue action just long enough for the crater to fill and end the weld properly by protecting the weld puddle from contamination.

c. An alternate technique for ending a GMAW weld is to reverse the travel direction before breaking the arc.

Note: The alternate technique is essential for welding out of corners where the weld has to start at a corner and be completed at a more accessible point.

Figure 21



Courtesy of Praxair, Inc.

d. After breaking the arc, keep the gun in place briefly so the crater will be shielded until it completely solidifies.

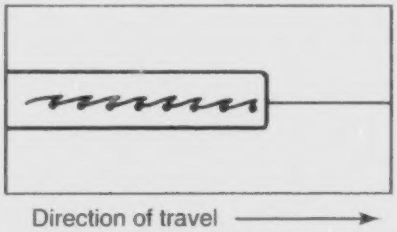
Objective 24

Techniques for position welding with GMAW

a. For single-pass butt joints in the flat position, use a slight back-stepping motion, but for flat position open-root butt joints, use a small weave.

Example: For a single pass square-groove butt joint, use a travel angle of 5° to 10° and a work angle of 90°.

Figure 22

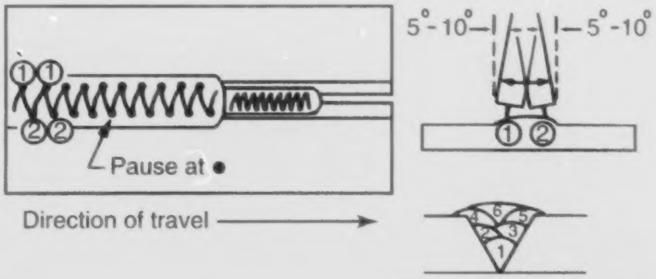


Courtesy of Praxair, Inc.

b. For fill and cover passes in the flat position, weave to desired width.

Example: For a multi-pass V-groove butt joint, use a travel angle of 5° to 10° and a work angle of 90°.

Figure 23



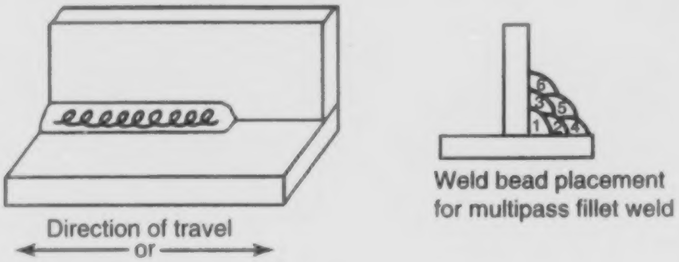
Weld bead placement for multipass butt weld

Courtesy of Praxair, Inc.

c. For fillet welds in the horizontal position, use a circular weave.

Example: Use a travel angle of 5° to 10° and a work angle of 45°.

Figure 24

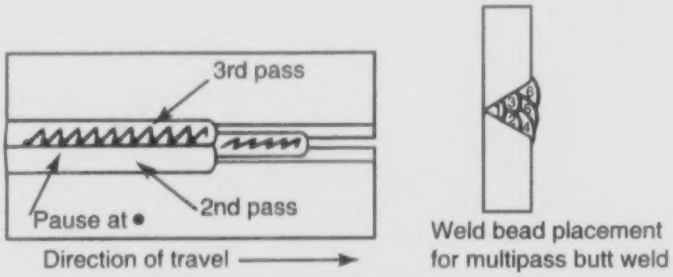

Direction of travel
or
Weld bead placement for multipass fillet weld

Courtesy of Praxair, Inc.

d. For V-groove butt joints in the horizontal position, use a weave to accomplish the desired width.

Example: For a V-groove butt joint, use a travel angle of 5° to 10° and a work angle of 90°.

Figure 25

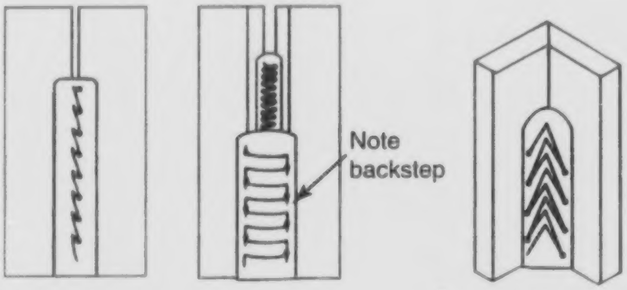

3rd pass
Pause at ●
2nd pass
Direction of travel
Weld bead placement for multipass butt weld

Courtesy of Praxair, Inc.

e. For both single-pass and multi-pass groove welds, and for fillet welds in the vertical up position, use a weaving technique.

Example: Use a travel angle of 10° to 15° and a work angle of 90°.

Figure 26

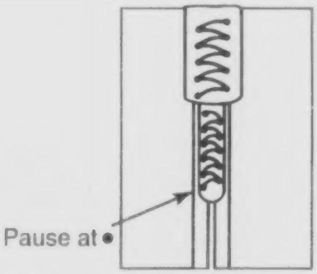

Note backstep

Courtesy of Praxair, Inc.

f. For all welds in the vertical down position, take special care to keep the arc in the leading edge of the puddle so the molten metal will not run around the arc and cause cold lapping.

Example: Use a travel angle of 5° to 10° and a work angle of 90°. Use a weave technique for fillet welds and for single-pass V-groove welds. Fill and cover with same weave technique.

Figure 27



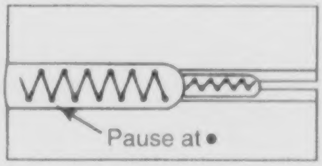
* Be sure to angle gun toward walls when weaving.

Courtesy of Praxair, Inc.

g. For both groove and fillet welds in the overhead position, use a weaving technique.

Example: Use a travel angle of 5° to 10° and a work angle of 90°.

Figure 28



* Be sure to angle gun toward walls when weaving.

Courtesy of Praxair, Inc.

Objective 25

Conditions that require special attention with GMAW

a. Base metal cleanliness is more critical with GMAW than with some other welding processes.

Examples: Both SMAW and SAW have fluxing compounds that scavage and cleanse the molten weld deposit of oxides and gas-forming compounds. GMAW does not provide such action.

b. Preweld and interpass cleaning are essential for GMAW, and especially for aluminum where chemical cleaning and/or mechanical removal of metallic oxides may be required.

c. The reduced heat input common to short circuit GMAW results in low penetration into the base metal, and may result in incomplete fusion if an improper welding technique is used.

Note: Reduced heat input is desirable on thin gauge materials and for out-of-position welding, but incomplete fusion can still occur, especially in root areas or along groove faces.

d. Oil, grease, and drawing compounds on the electrode wire or the base metal can become potential sources of hydrogen pick-up in a base metal.

e. GMAW shielding gases should be low in moisture content and the welding facility should be free of contaminants.

f. Weld problems such as undercutting, porosity, incomplete fusion, and incomplete joint penetration should be properly identified and corrected.

Note: The charts in the following five objectives present possible causes and corrective actions for common GMAW problems.

Objective 26

Possible causes and corrective actions for undercutting

Undercutting	
Possible Causes	Corrective Actions
Travel speed too high	Reduce travel speed.
Welding voltage too high	Reduce voltage.
Excessive welding current	Reduce wire feed speed.
Gun angle	Change gun angle so that arc force can aid in metal placement.

205

Objective 27

Possible causes and corrective actions for porosity

Porosity	
Possible Causes	Corrective Actions
Inadequate shielding gas coverage	Increase gas flow to displace air from the weld zone, or decrease gas flow to avoid turbulence and air entrapment in the weld zone
Gas contaminants	Use welding grade shielding gases.
Electrode contamination	Use only clean, dry electrode wire.
Workpiece contamination	Perform better preweld cleaning. Use more highly deoxidizing electrode wire.
Arc voltage too high	Reduce voltage.
Excess contact tube-to-work distance	Reduce electrode extension.

Objective 28

Possible causes and corrective actions for incomplete fusion

Incomplete Fusion	
Possible Causes	Corrective Actions
Weld zone surfaces not free of silt or excessive oxides	Clean weld zone surface free of mill scale before welding.
Insufficient heat input	Increase wire feed speed and arc voltage, and reduce electrode extension.
Too large a weld puddle	Minimize weaving to produce a more controllable weld puddle. Increase travel speed.
Improper weld technique	Keep electrode directed at the leading edge of the puddle. When weaving, dwell momentarily on the side walls of grooves. Provide improved access to roots of joints.
Improper joint design	Use angle groove large enough to allow access to bottom of the groove and sidewalls with proper extension, or use "U" or "J" groove.
Excessive travel speed	Reduce travel speed.

Information Sheet

Objective 29

Possible causes and corrective actions for incomplete joint penetration

Incomplete Joint Penetration

Possible Causes	Corrective Actions
Improper joint preparation	Provide proper access to the bottom of the groove while maintaining proper electrode extension. Reduce excessively large root face. Increase the root gap in butt joints, and increase the depth of back gouge.
Improper weld technique	Maintain electrode angle normal to work surface to achieve maximum penetration. Keep arc on leading edge of puddle.
Inadequate welding current	Increase the wire feed speed.

Objective 30

Possible causes and corrective actions for excessive melt-through

Excessive Melt-Through

Possible Causes	Corrective Actions
Excessive heat input	Reduce wire feed speed and voltage. Increase travel speed.
Improper joint preparation	Reduce root opening. Increase root face dimensions.

Objective 31

Flow meters and their use in GMAW

a. Flow meters regulate the flow of low pressure gases used in GMAW.

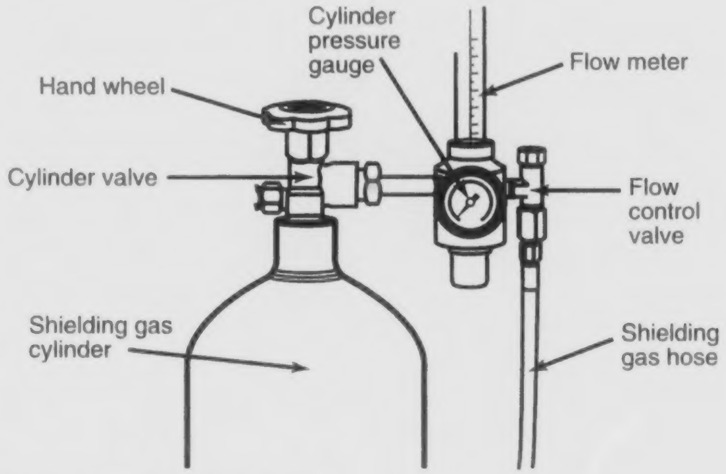
b. Flow meters measure gas flow in cubic feet per hour and are calibrated with an adjusting valve on the meter itself.

c. Floating-ball flow meters must be operated only in the vertical position.

d. A regulator should be used between the gas supply and the flow meter to assure uniform input pressure to the flow meter.

Note: A regulator delivers constant working pressure regardless of variations at the gas source, and dual stage regulators do an even better job when source pressure varies. Some regulators also have a built-in flow meter.

Figure 29



Courtesy of Lincoln Electric Company.

e. Gas mixtures are available in single cylinders, but gas from separate cylinders can be used with percentages calibrated through a mixer.

Objective 32

Flow rates for GMAW shielding gases

a. Flow rates for GMAW shielding gases are subject to many variables.

b. Metal thickness and joint design are important considerations as well as wire diameter, current, and wire feed speed.

c. As welding progresses, electrode extension, travel speed and angle, and environmental conditions may dictate flow rate changes.

Note: See Student Supplement 6 for flow rate recommendations related to to other typical conditions for GMAW applications.

Objective 33

Guidelines for troubleshooting GMAW problems

a. Try to isolate electrical or mechanical problems from process problems.

Example: Problems with arc control may be electrical, but they could also be caused by air drafts in the workplace.

b. Change only one variable at a time so you can use a logical process of elimination without creating a totally different problem.

c. Don't make hasty decisions about the source of a problem.

Example: If you replace a gas solenoid valve to solve a problem with gas flow, you will not feel extremely intelligent when you discover that the real problem was an empty gas cylinder.

d. Follow manufacturer's troubleshooting guidelines for all equipment.

e. Observe all safety rules when troubleshooting, especially when troubleshooting electrical problems.

Note: See Student Supplement 7 for GMAW troubleshooting guidelines as outlined by the American Welding Society.

Student Supplement 1—Recommended Electrodes for GMAW

Base metal type	Recommended electrode		AWS filler metal specification (use latest edition)	Electrode diameter		Current range Amperes
	Material type	Electrode classification		in.	mm	
Aluminum and aluminum alloys	1100 3003, 3004 5052, 5454 5083, 5086, 5456 6061, 6063	ER1100 or ER4043 ER1100 or ER5356 ER5554, ER5356, or ER5183 ER5556 or ER5356 ER4043 or ER5356	A5.10	0.030 3/64 1/16 3/32 1/8	0.8 1.2 1.6 2.4 3.2	50–175 90–250 160–350 225–400 350–475
Magnesium alloys	AZ10A AZ31B, AZ61A, AZ80A ZE10A ZK21A AZ63A, AZ81A AZ91C AZ92A, AM100A HK31A, HM21A HM31A LA141A	ERAZ61A, ERAZ92A ERAZ61A, ERAZ92A ERAZ61A, ERAZ92A ERAZ61A, ERAZ92A ERAZ92A ERAZ92A EREZ33A EREZ33A	A5.19	0.040 3/64 1/16 3/32 1/8	1.0 1.2 1.6 2.4 3.2	150–300^2 160–320^2 210–400^2 320–510^2 400–600^2
Copper and copper alloys	Silicon Bronze Deoxidized copper Cu-Ni alloys Aluminum bronze Phosphor bronze	ERCuSi-A ERCu ERCuNi ERCuA1-A1, A2 or A3 ERCuSn-A	A5.7	0.035 0.045 1/16 3/32	0.9 1.2 1.6 2.4	150–300 200–400 250–450 350–550
Nickel and nickel alloys	Monel^3 Alloy 400 Inconel^3 Alloy 600	ERNiCu-7 ERNiCrFe-5	A5.14	0.020 0.030 0.035 0.045 1/16	0.5 0.8 0.9 1.2 1.6	— — 100–160 150–260 100–400
Titanium and titanium alloys	Commercially pure Ti-0.15Pd Ti-5A1-2.5Sn	Use a filler metal one or two grades lower ERTi-0.2 Pd ERTi-5A1-2.5Sn or comm. pure	A5.16	0.030 0.035 0.045	0.8 0.9 1.2	— — —
Austenitic stainless steels	Type 201 Types 301, 302, 304, & 308 Type 304L Type 310 Type 316 Type 321 Type 347	ER308 ER308 ER308L ER310 ER316 ER321 ER347	A5.9	0.020 0.025 0.030 0.035 0.045 1/16 5/64 3/32 7/64 1/8	0.5 0.6 0.8 0.9 1.2 1.6 2.0 2.4 2.8 3.2	— — 75–150 100–160 140–310 280–450 — — — —

Student Supplement 1

Base metal type	Recommended electrode		AWS filler metal specification (use latest edition)	Electrode diameter		Current range Amperes
	Material type	Electrode classification		in.	mm	
Steel	Hot rolled or cold-drawn plain carbon steels	ER70S-3 or ER70S-1 ER70S-2, ER70S-4 ER70S-5, ER70S-6	A5.18	0.020	0.5	—
				0.025	0.6	—
				0.030	0.8	40–220
				0.035	0.9	60–280
				0.045	1.2	125–380
				0.052	1.3	260–460
				1/16	1.6	275–450
				5/64	2.0	—
				3/32	2.4	—
				1/8	3.2	—
Steel	Higher strength carbon steels and some low alloy steels	ER80S-D2 ER80S-Ni1 ER100S-G	A5.28	0.035	0.9	60–280
				0.045	1.2	125–380
				1/16	1.6	275–450
				5/64	2.0	—
				3/32	2.4	—
				1/8	3.2	—
				5/32	4.0	—

[2] Spray Transfer Mode

[3] Trademark—International Nickel Co.

Courtesy of Lincoln Electric Company.

Student Supplement 2—Surface Tension Transfer Process

Surface Tension Transfer

The Surface Tension Transfer (STT) process most closely resembles short arc welding but with one important difference. In standard short arc "MIG" welding the welding wire is fused open from the weld puddle by the application of high pinch currents. These high currents vaporize the wire and send small balls of molten wire flying through the air.

In the STT process, while the pinch current is being applied a calculation is done which is able to determine when the wire is about to fuse open. Just prior to the "mini explosion" the pinch current is reduced from around 500 amps to less than 100 amps, in millionths of a second, and the forces which were present to fuse open the wire continue and cause the wire to separate at a low current, avoiding the violent separation described above. Next, additional circuits detect that an arc has been reestablished and a peak current is applied to wet in the puddle and prevent cold fusion. Finally, the peak current is reduced in a controlled manner to a level which will allow the wire to short again and start the process over. This series of events occur about eighty to one-hundred twenty times a second. Unlike pulse welding where the operator determines the pulses per second, STT pulses are determined by the natural shorting rate of the wire for a given process.

One additional feature to the "natural pulse rate" is the fact that changing the wire speed of the STT process will change the shorting rate and therefore the average current. This gives the operator a great deal of range of wire feed speed for only one setting of peak and background.

By utilizing Waveform Control Technology, STT has the capability of delivering and changing electrode current in the order of microseconds. Precise control of the electrode current during the entire welding cycle minimizes or eliminates the main disadvantages of conventional GMAW short arc welding. This revolutionary process is neither one of constant voltage (CV) or constant current (CC). STT is a welding mode where the electrode current is based on the instantaneous heat requirements of the arc.

STT can be used with a variety of welding consumables including solid and steel and stainless alloys, high nickel alloys, and silicon bronze. When using typical gas blends, less spatter is generated than with conventional GMAW. In fact when using CO_2 on mild and most alloy steels, the STT produces less spatter than conventional GMAW with argon blends. It is designed for challenging semiautomatic and automatic applications and can be easily adapted to robotics. For problems with spatter, smoke, burnthrough, heat input, high-low, poor fit-up, high repair rates, and over welding, STT may be the solution.

Student Supplement 2

STT Waveform

- Background current—Controls bead shape and provides minimum heat to maintain a liquid ball (T7–T1)
- Peak current—Controls arc length and promotes good fusion (T5–T6)
- Tailout—Reduces puddle agitation, eliminates premature shorts, and smoothes bead (time between T6–T7)

Major Advantages

Low Heat Input	→	Reduced Distortion
Minimal Spatter	→	Reduced Cleaning
Bead Contour	→	Less Grinding
Process Efficiency	→	Fusion Even on Gaps
Over Welding	→	Smaller Welds
Uses Larger Wire	→	Lower Cost
Can Use CO_2	→	Lower Cost
Easy	→	Minimal Training
Environmental	→	Less Smoke

Information in this student supplement is courtesy of Lincoln Electric Company.

Student Supplement 3—Inverter Technology

Inverter technology is used on many types of welding machines. One example of inverter technology that is discussed in this unit is surface tension transfer. What makes inverter technology unique is its ability to switch from peak to background current at over 40 Khz. This high speed switching controls metal transfer while sampling the voltage to control the arc length.

Advantages

- More efficient
- Lightweight
- Smaller size
- Superior arc characteristics
- Advanced technology

Limitations

- Small
- "Newer" technology
- DC output only

Inverter Sequence

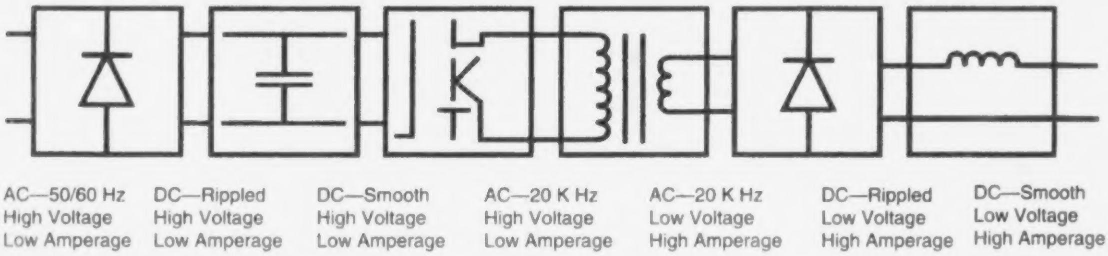
- Input power = AC at high voltage, low amperage
- Rectifier = Changes AC to DC, high V, low A
- Filter/choke = Takes this rippled DC and smoothes it out, high V, low A
- IGBT/FET (Insulated Gate Bipolar Transistor/Field Effect Transistor) = Changes this DC back to AC and elevates the frequency from 60 Hz to 20,000 Hz, high V, low A
- Transformer = Takes this AC at high V, low A and "transforms" it to low V, high A suitable for welding
- Rectifier = Changes this AC at low V, high A suitable for welding and changes it to DC
- Filter/Choke = Takes this rippled DC and smoothes it out at low V, high A suitable for welding

Student Supplement 3

Efficiency Data

- 60 Hz—Weight of transformer = 19.5 lb, 90% efficient—Standard transformer design
- 20,000 Hz—Weight of transformer = 1.5 lb, 99% efficient—Surface Tension Transfer

Inverter Technology


AC—50/60 Hz
High Voltage
Low Amperage
DC—Rippled
High Voltage
Low Amperage
DC—Smooth
High Voltage
Low Amperage
AC—20 K Hz
High Voltage
Low Amperage
AC—20 K Hz
Low Voltage
High Amperage
DC—Rippled
Low Voltage
High Amperage
DC—Smooth
Low Voltage
High Amperage

Information in this student supplement is courtesy of Lincoln Electric Company.

Student Supplement 4—Recommended Initial Settings for STT

Table 1—All Position Welding .045″ L-50 and L-56 with Carbon Dioxide Shielding Gas[1]

Material size	Wire Feed Speed (in/min.)	Peak Current Control Setting	Background Current Control Setting	Travel Speed (in/min.)	Tip to Plate Distance (in)	Welding Current (approx. AMPS)	Tailout[2] (adjustable)
3/16″	175	440	75	10–11	1/4—5/16	230	0–10
10 ga.	150	400	60	12–13	1/4—5/16	200	0–10
12 ga.	110	390	40	13–14	1/4—5/16	175	0–10
14 ga.	100	380	30	11–12	1/4—5/16	160	0–10
16 ga.	65	235	40	11–12	1/4—5/16	125	0–10

[1] Shielding gas flow rate of 25 CFH

[2] Tailout increases travel speed and increases wetting

Table 2—Pipe Welding 3/8″ Thickness Maximum .045″ L-50 and L-56 with Carbon Dioxide Shielding Gas[1]

Pass Hot/Fill Cap	Wire Feed Speed (in/min.)	Peak Current Control Setting	Background Current Control Setting	Travel Speed (in/min.)	Tip to Plate Distance (in)	Welding Current (approx. AMPS)	Tailout[2] (adjustable)
Root Pass Vertical Down	120	370	25	8–9	1/4	200	0–10
Root Pass Vertical Up	75	275	40	3–4	1/4	130	0–10
Fill Pass Vertical Up	120	370	50	3	1/4	210	0–10
Cap Pass Vertical Up	120	370	50	3	1/4	210	0–10

Vertical-up procedures are recommended for top (12 to 2 o'clock) and overhead (4 to 6 o'clock) positions.

[1] Shielding gas flow rate of 25 CFH

[2] Tailout increases travel speed and increases wetting

Student Supplement 4

Table 3—All Position Welding .035″ L-50 and L-56 with Carbon Dioxide Shielding Gas[1]

Material size	Wire Feed Speed (in/min.)	Peak Current Control Setting	Background Current Control Setting	Travel Speed (in/min.)	Tip to Plate Distance (in)	Welding Current (approx. AMPS)	Tailout[2] (adjustable)
3/16″	250	420	50	13–14	1/4—5/16	190	0–10
10 ga.	235	400	40	14–15	1/4—5/16	185	0–10
12 ga.	220	390	35	16–17	1/4—5/16	180	0–10
14 ga.	210	380	30	17–18	1/4—5/16	175	0–10
16 ga.	190	360	30	19–20	1/4—5/16	170	0–10
18 ga.	90	320	25	11–12	1/4—5/16	115	0–10
20 ga.	80	295	25	12–13	1/4—5/16	100	0–10

[1] Shielding gas flow rate of 25 CFH

[2] Tailout increases travel speed and increases wetting

Table 4—All Position Welding .030″ L-50 and L-56 with Carbon Dioxide Shielding Gas[1]

Material size	Wire Feed Speed (in/min.)	Peak Current Control Setting	Background Current Control Setting	Travel Speed (in/min.)	Tip to Plate Distance (in)	Welding Current (approx. AMPS)	Tailout[2] (adjustable)
12 ga.	250	300	50	16–17	1/4—5/16	140	0–10
14 ga.	235	290	45	16–17	1/4—5/16	135	0–10
16 ga.	175	275	35	16–17	1/4—5/16	125	0–10
18 ga.	150	250	25	15–16	1/4—5/16	110	0–10
20 ga.	90	220	30	11–12	1/4—5/16	70	0–10

[1] Shielding gas flow rate of 25 CFH

[2] Tailout increases travel speed and increases wetting

Table 5—All Position Welding .045″ L-50 and L-56 with 75% Argon/25% Carbon Dioxide Shielding Gas

Material size	Wire Feed Speed (in/min.)	Peak Current Control Setting	Background Current Control Setting	Travel Speed (in/min.)	Tip to Plate Distance (in)	Welding Current (approx. AMPS)	Tailout[1] (adjustable)
3/16″	175	358	120	10–11	1/4—5/16	200	0–10
10 ga.	150	354	90	12–13	1/4—5/16	190	0–10
12 ga.	110	326	68	11–12	1/4—5/16	150	0–10
14 ga.	100	296	66	11–12	1/4—5/16	140	0–10

[1] Tailout increases travel speed and increases wetting

Table 6—All Position Welding .035″ L-50 and L-56 with 75% Argon/25% Carbon Dioxide Shielding Gas

Material size	Wire Feed Speed (in/min.)	Peak Current Control Setting	Background Current Control Setting	Travel Speed (in/min.)	Tip to Plate Distance (in)	Welding Current (approx. AMPS)	Tailout[1] (adjustable)
3/16″	300	300	105	10–12	1/4—5/16	195	0–10
10 ga.	235	300	80	14–15	1/4—5/16	185	0–10
12 ga.	220	285	80	16–17	1/4—5/16	180	0–10
14 ga.	210	280	75	19–20	1/4—5/16	175	0–10
16 ga.	190	260	70	17–18	1/4—5/16	160	0–10
18 ga.	90	200	39	12–13	1/4—5/16	105	0–10

[1] Tailout increases travel speed and increases wetting

The tables in this student supplement are courtesy of Lincoln Electric Company.

Student Supplement 5—Recommended GMAW Shielding Gases

Table 1—Selection of gases for GMAW with short circuiting transfer

Metal	Shielding gas	Advantages
Carbon steel	75% argon +25% CO_2	Less than 1/8 in. (3.2 mm) thick: high welding speeds without burn-thru; minimum distortion and spatter.
	75% argon +25% CO_2	More than 1/8 in. (3.2 mm) thick: minimum spatter; clean weld appearance; good puddle control in vertical and overhead positions.
	CO_2	Deeper penetration; faster welding speeds.
Stainless steel	90% helium + 7.5% argon + 2.5% CO_2	No effect on corrosion resistance; small heat-affected zone; no undercutting; minimum distortion.
Low alloy steel	60–70% helium + 25–35% argon + 4–5% CO_2	Minimum reactivity; excellent toughness; excellent arc stability, wetting characteristics, and bead contour; little spatter.
	75% argon + 25% CO_2	Fair toughness; excellent arc stability, wetting characteristics, and bead contour, little spatter.
Aluminum, copper, magnesium, nickel, and their alloys	Argon & argon + helium	Argon satisfactory on sheet metal; argon-helium preferred on thicker sheet material (over 1/8 in. [3.2mm]).

Courtesy of Lincoln Electric Company.

Table 2—Selection of gases for GMAW with spray and pulsed-spray transfer

Metal	Shielding gas	Advantages
Aluminum	Argon	0 to 1 in. (0 to 25 mm) thick: best metal transfer and arc stability; least spatter.
	35% argon + 65% helium	1 to 3 in. (25 to 76 mm) thick: higher heat input than straight argon; improved fusion characteristics with 5XXX series Al-Mg alloys.
	25% argon + 75% helium	Over 3 in. (76 mm) thick: highest heat input; minimizes porosity.
Magnesium	Argon	Excellent cleaning action.
Carbon steel	Argon + 1–5% oxygen	Improves arc stability; produces a more fluid and controllable weld puddle; good coalescence and bead contour; minimizes undercutting; permits higher speeds than pure argon.
	Argon + 3–10% CO_2	Good bead shape; minimizes spatter; reduces chance of cold lapping; cannot weld out-of-position.
Low-alloy steel	Argon + 2% oxygen	Minimizes undercutting; provides good toughness.
Stainless steel	Argon + 1% oxygen	Improves arc stability; produces a more fluid and controllable weld puddle, good coalescence and bead contour; minimizes undercutting on heavier stainless steels.
	Argon + 2% oxygen	Provides better arc stability, coalescence, and welding speed than 1 percent oxygen mixture for thinner stainless steel materials.
Copper, nickel and their alloys	Argon	Provides good wetting; decreases fluidity of weld metal for thickness up to 1/8 in. (3.2mm).
	Argon + helium	Higher heat inputs of 50 & 75 percent helium offset high heat dissipation of heavier gages.
Titanium	Argon	Good arc stability; minimum weld contamination; inert gas backing is required to prevent air contamination on back of weld area.

Courtesy of Lincoln Electric Company.

220

Table 3—Selection of gases for GMAW with surface tension transfer

Metal	Shielding gas	Advantages
Carbon steel	75% argon +25% CO_2	Less than 1/8 in. (3.2 mm) thick: high welding speeds without burn-thru; minimum distortion and spatter.
	75% argon +25% CO_2	More than 1/8 in. (3.2 mm) thick: minimum spatter; clean weld appearance; good puddle control in vertical and overhead positions.
	CO_2	Deeper penetration; faster welding speeds.
Stainless steel and nickel alloy	90% helium + 7.5% argon + 2.5% CO_2	No effect on corrosion resistance; small heat-affected zone; no undercutting; minimum distortion.
Low alloy steel	60–70% helium + 25–35% argon + 4–5% CO_2	Minimum reactivity; excellent toughness; excellent arc stability, wetting characteristics, and bead contour; little spatter.
	75% argon + 25% CO_2	Fair toughness; excellent arc stability, wetting characteristics, and bead contour, little spatter.

Courtesy of Lincoln Electric Company.

Student Supplement 6—Gas Metal Arc Welding Conditions

Table 4.8

Typical Conditions for Gas Metal Arc Welding of Carbon and Low Alloy Steel in the Flat Position

Material Thickness			Wire Diameter		Current Voltage[1]		Wire Feed Speed			Gas Flow	
in.	mm	Type of Weld	in.	mm	amps	volts	IPM	mm/s	Shielding Gas[2]	CFH	LPM
.062	1.6	Butt[3]	.035	0.9	95	18	150	64	Ar 75%, CO^2–25%	25	12
.125	3.2	Butt[3]	.035	0.9	140	20	250	106	Ar 75%, CO^2 25%	25	12
.187	4.7	Butt[3]	.035	0.9	150	20	265	112	Ar 75%, CO^2 25%	25	12
.250	6.4	Butt[3]	.035	0.9	150	21	265	112	Ar 75%, CO^2 25%	25	12
.250	6.4	Butt[4]	.045	1.1	200	22	250	106	Ar 75%, CO^2–25%	25	12

1. Direct current electrode positive.
2. Welding grade CO2 may also be used.
3. Root opening of .03 in. (0.8mm)
4. Root opening of .062 in. (1.6mm)

Table 4.9

Typical Conditions for Gas Metal Arc Welding of Aluminum in the Flat Position

Material Thickness			Wire Diameter		Current Voltage*		Wire Feed Speed			Gas Flow	
in.	mm	Type of Weld	in.	mm	amps	volts	IPM	mm/s	Shielding Gas	CFH	LPM
.062	1.6	Butt	.030	0.8	90	18	365	155	Argon	30	14
.125	3.2	Butt	.030	0.8	125	20	440	186	Argon	30	14
.187	4.8	Butt	.045	1.1	160	23	275	116	Argon	35	16
.250	6.4	Butt	.045	1.1	205	24	335	142	Argon	35	16
.375	9.5	Butt	.063	1.6	240	26	215	91	Argon	40	19

* Direct current electrode positive.

Courtesy of the American Welding Society.

Student Supplement 7—
GMAW/Microprocessor Troubleshooting

Note: The AWS troubleshooting guidelines are arranged on single pages so they can be placed alongside each other to afford a better overall view of how problems overlap. In other words, an electrical problem may be the result of a mechanical problem, or a process problem the result of a mechanical problem. The "systems" approach to troubleshooting will help solve problems that occur as welding is in progress. Problems with weld quality after the weld is made are covered in earlier objectives.

Student Supplement 7

Troubleshooting Electrical Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Difficult arc starting	Wrong polarity Poor work lead connection	Check polarity; reverse leads if necessary. Secure work lead connection
Irregular wire feed and burnback	Power circuit fluctuations Polarity wrong	Check line voltage Check polarity; reverse leads if necessary
Welding cables overheating	Cables are too small or too long Cable connections loose	Check current carrying requirements—replace or shorten if necessary Tighten
No wire feed speed control	Broken or loose wires in control circuit Bad P.C. board in governor	Check and repair if necessary Replace P.C. board
Unstable arc	Cable connections are loose	Tighten connections
Electrode won't feed	Control circuit fuse blown Fuse blown in power source Defective gun trigger switch or broken wire leads Drive motor burned out	Replace fuse Replace fuse Check connections; replace switch Check and replace
Wire feeds but no gas flows	Failure of gas valve solenoid Loose or broken wires to gas valve solenoid	Replace Check and repair if necessary
Electrode wire feed but is not energized (no arc)	Poor workpiece connection Loose cable connections Primary contactor coil or points defective Contactor control leads broken	Tighten if loose; clean work of paint, rust, etc. Tighten Repair or replace Repair or replace
Porosity in weld	Loose or broken wires to gas solenoid valve	Repair or replace
No control of wire feed speed (microprocessor)	Defective control board	Replace control board
Preset arc voltage does not match actual voltage (microprocessor)	Control board may be faulty	Make sure the power source is set for remote voltage control

Courtesy of the American Welding Society.

Troubleshooting Mechanical Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Irregular wire feed and burnback	Insufficient drive roll pressure	Adjust
	Contact tube plugged or worn	Clean or replace
	Kinked electrode wire	Cut out, replace spool
	Coiled gun cable	Straighten cables, hang the wire feeder
	Conduit liner dirty or worn	Clean or replace
	Conduit too long	Shorten or use push-pull drive system
Electrode wire wraps around drive roll (•birdnesting•)	Excessive feed roll pressure	Adjust
	Incorrect conduit liner or contact tip	Match liner and contact tip to electrode size
	Misaligned drive rolls or wire guides	Check and align properly
	Restriction in gun or gun cable	Remove restriction
Heavily oxidized weld deposit	Air/water leaks in gun and cables	Check for leaks and repair or replace as necessary
	Restricted shield gas flow	Check and clean nozzle
Electrode wire stops feeding while welding	Excess or insufficient drive roll pressure	Adjust
	Wire drive rolls misaligned or worn	Realign and/or replace
	Liner or contact tube plugged	Clean or replace
Wire feeds but no gas flows	Gas cylinder is empty	Replace and purge lines before welding
	Gas cylinder valve closed	Open cylinder valve
	Flow meter not adjusted	Adjust to give flow specified in the procedure
	Restriction in gas line or nozzle	Check and clean
Porosity in the weld bead	Failed gas valve solenoid	Repair or replace
	Gas cylinder valve closed	Turn valve on
	Insufficient shielding gas flow	Check for restrictions in gas line or nozzle and correct
	Leaks in gas supply lines (including the gun)	Check for leaks (especially at connections) and correct
Wire feed motor operates but wire does not feed or feeding rough	Insufficient drive roll pressure	Adjust
	Incorrect wire feed rolls	Match feed rolls to wire size and type
	Excessive pressure on wire spool brake	Decrease brake pressure
	Restriction in the conduit liner or gun	Check liner and contact tip Clean and/or replace
	Incorrect liner or contact tube	Check and replace with correct size
	DIP switches on microprocessor may be improperly selected	Reset DIP switches
Welding gun overheats	Pinched or clogged coolant line	Check and correct
	Low coolant level in pump reservoir	Check and add coolant as necessary
	Water pump not functioning correctly	Check and repair or replace

Courtesy of the American Welding Society

Troubleshooting Process Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Unstable arc	Weld joint area dirty	Clean to remove scale, rust, etc.
Heavily oxidized weld deposit	Improper gun angle Excessive nozzle to work distance distance Air drafts Contact tube not centered in gas nozzle distance	Use approximately 15° lead or trail angle Reduce. Should be approximately 1/2 to 3/4" Protect weld area from drafts Center contact tube
Porosity in the weld bead	Dirty base material Excessive wire feed speed Moisutre in the shielding gas Contaminated electrode	Clean to remove scale, rust, etc. Reduce Replace gas cylinder Keep wire protected while using. Clean wire before it enters feeder.
Electrode wire stubs into the workpiece	Excessive wire feed speed Arc voltage too low Excessive slope set on power source (for short circuiting transfer)	Reduce speed Increase voltage Reset to reduce slope
Excessive spatter	Excessive arc voltage Insufficient slope set on power source (for short circuiting transfer) Contact tube recessed too far in nozzle Excessive gas flow rate	Reduce voltage Increase slope setting Adjust or replace with longer one Reduce flow
Welding gun overheats	Excessive amperage for gun	Reduce amperage or change to higher capacity gun
Violent arc starting with melting of contact tip (STT Only)	Arc sense receptacle missing or loose connection	Make sure arc sense receptacle is firmly attached to workpiece

Courtesy of the American Welding Society.

Unit Contents

Student Components

Student Page

Learning Activities Sheet 3-3

Objective Sheet 3-9

Information Sheet 3-11

Student Supplements

1—Typical Operating Variables for Flux-Cored Electrodes 3-23
2—FCAW-GS Electrodes 3-25
3—AWS Classifications for FCAW Electrodes 3-27
4—FCAW Troubleshooting 3-29

*Job Sheets

1—Set Up or Replace Wire on a Flux-Cored Wire Feeder 175
2—Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding 179
3—Prepare Mild Steel for FCAW 181
4—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 183
5—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 187
6—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 191
7—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 195
8—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position 199
9—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position 203
10—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position 207
11—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position 211
12—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 215
13—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position 219
14—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position 223
15—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position 227

*Job Sheets are located in the Student Workbook.

Prerequisites:
Unit 1

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 4.

Optional ☐ 4. **View** Video entitled *Flux-Cored Arc Welding.*

☐ 5. **Study** Information Sheet, Objectives 5, 6, and 7, and Student Supplements 1 and 2.

Optional ☐ 6. **Research** Online resources regarding FCAW. Visit www.praxair.com as one of your sources.

☐ 7. **Study** Information Sheet, Objective 8, and Student Supplement 3.

☐ 8. **Study** Information Sheet, Objectives 9, 10, and 11.

☐ 9. **Observe** Demonstration of procedures to be used in completing Job Sheet 1.

☐ 10. **Do** Job Sheet 1, "Set Up or Replace Wire on a Flux-Cored Wire Feeder."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat steps 8, 9, and 10.

☐ 12. **Study** Information Sheet, Objectives 12 and 13.

☐ 13. **Observe** Demonstration of procedures to be used in completing Job Sheet 2.

Learning Activities Sheet

☐ 14. **Do** Job Sheet 2, "Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat steps 12, 13, and 14.

☐ 16. **Study** Information Sheet, Objective 14.

☐ 17. **Observe** Demonstration of procedures to be used in completing Job Sheet 3.

☐ 18. **Do** Job Sheet 3, "Prepare Mild Steel for FCAW."

☐ 19. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat steps 16, 17, and 18.

☐ 20. **Study** Information Sheet, Objectives 15, 16, and 17, and Student Supplement 4.

☐ 21. **Observe** Demonstration of procedures to be used in completing Job Sheet 4.

☐ 22. **Do** Job Sheet 4, "Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position."

☐ 23. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 24. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat steps 20, 21, and 22.

☐ 24. **Observe** Demonstration of procedures to be used in completing Job Sheet 5.

☐ 25. **Do** Job Sheet 5, "Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position."

☐ 26. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 27. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat steps 24 and 25.

☐ 27. **Observe** Demonstration of procedures to be used in completing Job Sheet 6.

☐ 28. **Do** Job Sheet 6, "Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position."

☐ 29. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 30. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 6 and repeat steps 27 and 28.

☐ 30. **Observe** Demonstration of procedures to be used in completing Job Sheet 7.

☐ 31. **Do** Job Sheet 7, "Weld to Specifications a Fillet T-Joint on Mild Steel in the Horizontal Position."

☐ 32. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 33. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 7 and repeat steps 30 and 31.

☐ 33. **Observe** Demonstration of procedures to be used in completing Job Sheet 8.

☐ 34. **Do** Job Sheet 8, "Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position."

☐ 35. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 36. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 8 and repeat steps 33 and 34.

☐ 36. **Observe** Demonstration of procedures to be used in completing Job Sheet 9.

☐ 37. **Do** Job Sheet 9, "Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position."

☐ 38. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 39. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 9 and repeat steps 36 and 37.

☐ 39. **Observe** Demonstration of procedures to be used in completing Job Sheet 10.

☐ 40. **Do** Job Sheet 10, "Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position."

Learning Activities Sheet

☐ 41. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 42. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 10 and repeat steps 39 and 40.

☐ 42. **Observe** Demonstration of procedures to be used in completing Job Sheet 11.

☐ 43. **Do** Job Sheet 11, "Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position."

☐ 44. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 45. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 11 and repeat steps 42 and 43.

☐ 45. **Observe** Demonstration of procedures to be used in completing Job Sheet 12.

☐ 46. **Do** Job Sheet 12, "Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position."

☐ 47. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 48. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 12 and repeat steps 45 and 46.

☐ 48. **Observe** Demonstration of procedures to be used in completing Job Sheet 13.

☐ 49. **Do** Job Sheet 13, "Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position."

☐ 50. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 51. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 13 and repeat steps 48 and 49.

☐ 51. **Observe** Demonstration of procedures to be used in completing Job Sheet 14.

☐ 52. **Do** Job Sheet 14, "Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position."

☐ 53. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 54. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 14 and repeat steps 51 and 52.

☐ 54. **Observe** Demonstration of procedures to be used in completing Job Sheet 15.

☐ 55. **Do** Job Sheet 15, "Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position."

☐ 56. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 57. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 15 and repeat steps 54 and 55.

☐ 57. **Check** With instructor for any additional assignments to be completed.

☐ 58. **Do** Additional assignments listed below.

____

____

____

☐ 59. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 60. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up equipment for flux-cored arc welding, and weld to specifications lap joints, T-joints, and V-groove butt joints in all positions on selected metals. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to flux-cored arc welding with their definitions.
2. Select true statements concerning advantages of FCAW.
3. Select true statements concerning limitations of FCAW.
4. Complete statements concerning how students benefit from learning FCAW.
5. Select true statements concerning equipment required for semiautomatic self-shielded FCAW.
6. Match types of flux-cored arc welding processes with their characteristics.
7. Complete statements concerning types of FCAW guns and their uses.
8. Solve problems concerning classifications for FCAW electrode wires.
9. Differentiate between electrode extension and visible electrode extension.
10. Solve problems concerning basic types of flux-cored wire feeders.
11. Select true statements concerning guidelines for using drive rolls and guide tubes.
12. Arrange in order the steps in starting an arc with the semiautomatic process.
13. Complete statements concerning operating variables with flux-cored electrode wires.
14. Solve problems concerning guidelines for preparing for FCAW applications.
15. Select true statements concerning guidelines for semiautomatic FCAW.
16. Complete statements concerning safety requirements for FCAW.
17. Solve problems concerning guidelines for troubleshooting FCAW problems.

Objective Sheet

*18. Set up or replace wire on a flux-cored wire feeder. (Job Sheet 1)

*19. Set up FCAW equipment for semiautomatic flux-cored welding. (Job Sheet 2)

*20. Prepare mild steel for FCAW. (Job Sheet 3)

*21. Weld to specifications a fillet weld lap joint on mild steel in the flat position. (Job Sheet 4)

*22. Weld to specifications a fillet weld T-joint on mild steel in the flat position. (Job Sheet 5)

*23. Weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (Job Sheet 6)

*24. Weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (Job Sheet 7)

*25. Weld to specifications a fillet weld lap joint on mild steel in the vertical position. (Job Sheet 8)

*26. Weld to specifications a fillet weld T-joint on mild steel in the vertical position. (Job Sheet 9)

*27. Weld to specifications a fillet weld lap joint on mild steel in the overhead position. (Job Sheet 10)

*28. Weld to specifications a fillet weld T-joint on mild steel in the overhead position. (Job Sheet 11)

*29. Weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 12)

*30. Weld to specifications a V-groove butt joint on mild steel in the horizontal position. (Job Sheet 13)

*31. Weld to specifications a V-groove butt joint on mild steel in the vertical position. (Job Sheet 14)

*32. Weld to specifications a V-groove butt joint on mild steel in the overhead position. (Job Sheet 15)

*Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Automatic**—An FCAW process where welding is controlled by mechanical devices programmed for specific applications

b. **Concentric**—Having a common center or a common axis

c. **FCAW (Flux-Cored Arc Welding)**—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux in the tubular electrode, and additional shielding may be obtained from an externally supplied gas

Note: Externally supplied gas or gas mixtures may or may not be used in FCAW, depending on the electrode used.

d. **Gas-shielded**—A flux-cored wire electrode used in the presence of a shielding gas to provide double protection and improved mechanical properties for the weld zone

e. **Metal core**—A GMAW process similar to FCAW except that a metal powder is located inside the wire instead of flux

f. **Self-shielded**—A flux-cored wire electrode that protects the weld zone from contaminants with fluxing elements released from the inner core of the wire itself as the arc is made

g. **Semiautomatic**—An FCAW process where welding is controlled as an operator squeezes or releases a gun trigger

Objective 2

Advantages of FCAW

a. FCAW can weld many metals over a wide thickness range.

b. FCAW creates less distortion and has up to four times greater deposition rate than SMAW.

c. FCAW offers high-quality weld metal deposits.

d. With FCAW, the visible arc makes for easy application with less effort on the part of the welder.

e. FCAW offers economically engineered joint designs.

f. FCAW is time-saving because it requires less precleaning than GMAW.

g. FCAW produces a smooth, uniform weld with excellent appearance.

h. FCAW offers a relatively high electrode deposit efficiency, a high deposition rate (high current density), and a high operating factor because it is easily mechanized.

i. With self-shielding electrodes, FCAW is seldom bothered by breezes and drafts.

j. FCAW has excellent contour of horizontal fillet welds.

k. FCAW has a higher tolerance for contaminants that may cause weld cracking.

l. FCAW is resistant to underbead cracking.

Objective 3

Limitations of FCAW

a. FCAW is currently limited to welding ferrous metals and nickel base alloys.

b. The FCAW process produces a slag covering which must be removed.

c. FCAW electrode wire is more expensive on a weight basis than solid electrode wires, except for some high alloy steels.

d. FCAW equipment is more expensive, more complex, and requires more maintenance than SMAW equipment, but increased productivity usually compensates for added FCAW costs.

e. The FCAW wire feeder and power source must be fairly close to the point of welding.

f. For the gas-shielded version, the external shield can be adversely affected by breezes and drafts.

g. FCAW requires cleanup after welding, and the process creates smoke and fumes in the workplace.

Note: Metal core produces less smoke and fumes than FCAW.

Objective 4

How students benefit from learning FCAW

a. The FCAW process introduces students to high deposition welding.

b. With FCAW, students learn manipulative skills for the fast welding speeds required for production-type welding.

c. Students who master FCAW will have additional opportunities because the FCAW process is popular in industry, and its use will continue to expand.

Objective 5

Equipment required for semiautomatic self-shielded FCAW

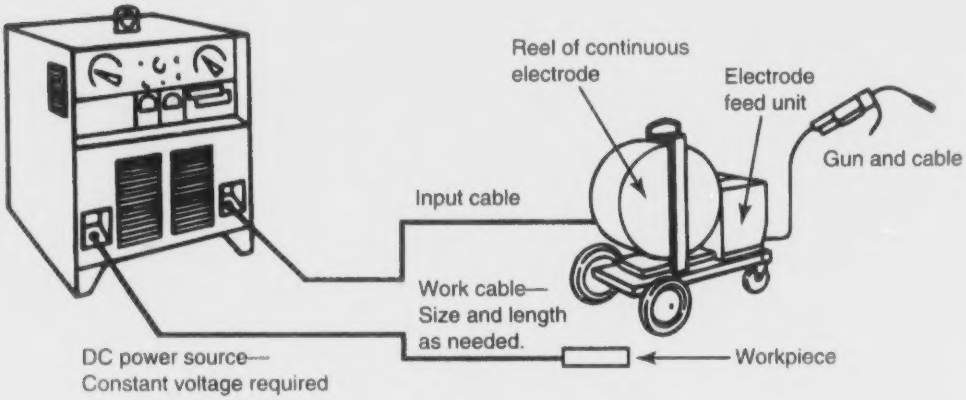
a. The FCAW process requires a constant voltage DC power source with a minimum amperage range of 200 to 400 amps.

b. The process requires an electrode input cable, a work cable, and ground.

c. FCAW requires a reel of continuous electrode wire and an electrode feed unit.

d. FCAW requires a gun and cable assembly.

Figure 1


Reel of continuous electrode
Electrode feed unit
Gun and cable
Input cable
Work cable—Size and length as needed.
Workpiece
DC power source—Constant voltage required

Courtesy of Lincoln Electric Company.

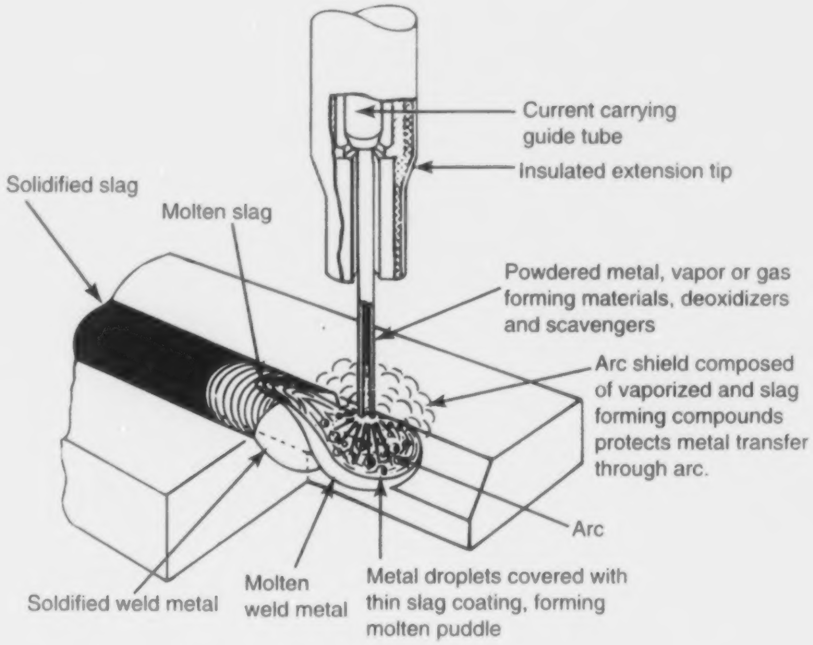
Information Sheet

Objective 6

Types of flux-cored arc welding processes

a. **Semiautomatic self-shielded**—A modification of the manual shielded metal-arc welding process except that the covered SMAW electrode is replaced with a continuous flux-cored electrode that is fed through a gun instead of an electrode holder

Figure 2

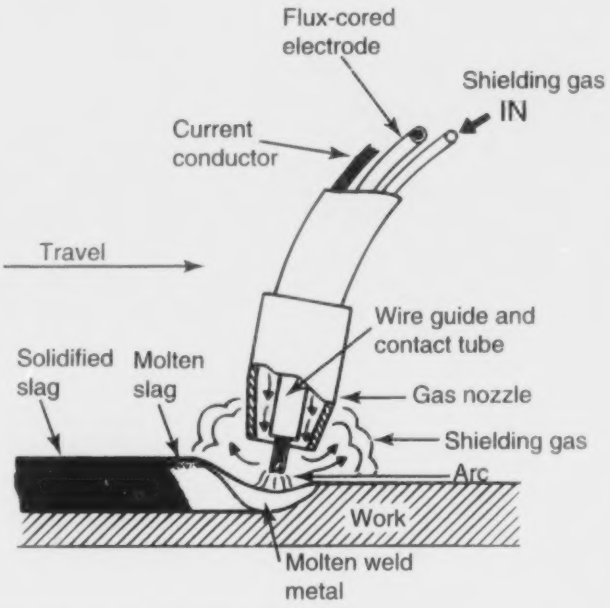

Current carrying guide tube
Insulated extension tip
Solidified slag
Molten slag
Powdered metal, vapor or gas forming materials, deoxidizers and scavengers
Arc shield composed of vaporized and slag forming compounds protects metal transfer through arc.
Arc
Soldified weld metal
Molten weld metal
Metal droplets covered with thin slag coating, forming molten puddle

Courtesy of Lincoln Electric Company.

b. **Automatic self-shielded**—A modification of the semiautomatic self-shielded process that replaces manual manipulation with programmed, mechanized components

c. **Gas-shielded flux-cored**—A welding process similar to both SMAW and GMAW, but different than SMAW in that CO_2 is usually used as a shielding gas in a dual function with the electrode flux, and different from GMAW in that the electrode wire is tubular instead of solid

Figure 3


Flux-cored electrode
Shielding gas IN
Current conductor
Travel
Wire guide and contact tube
Solidified slag
Molten slag
Gas nozzle
Shielding gas
Arc
Work
Molten weld metal

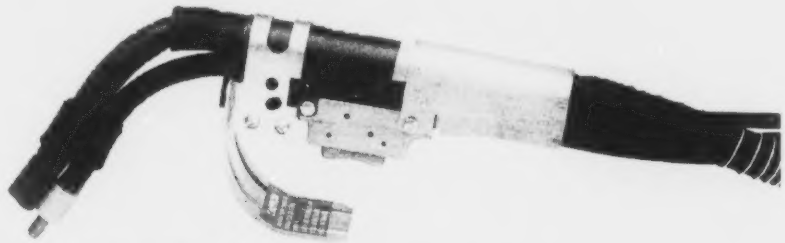
Courtesy of Lincoln Electric Company.

Objective 7

Types of FCAW guns and their uses

a. Straight nozzle guns are used for the self-shielded process, mostly on fillet welds and on applications where the work flows under the gun.

Figure 4



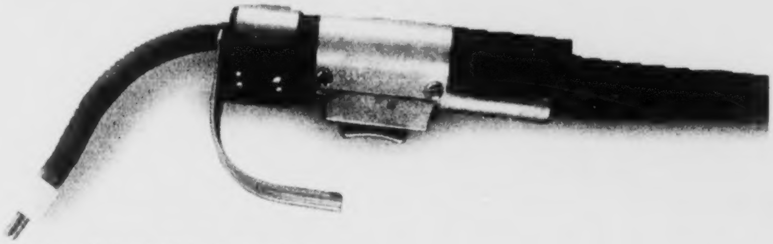
Courtesy of Lincoln Electric Company.

239

b. Curved-nozzle guns are used in the self-shielding process, mostly for welding heavy metals because curved nozzle guns are flexible and easy to manipulate.

Note: Reverse bend guns are used for self-shielded wire.

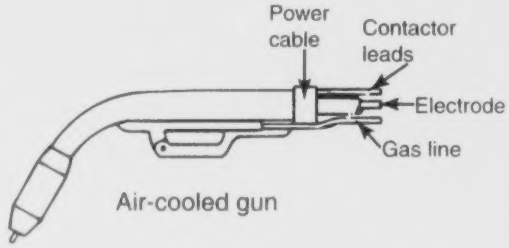
Figure 5



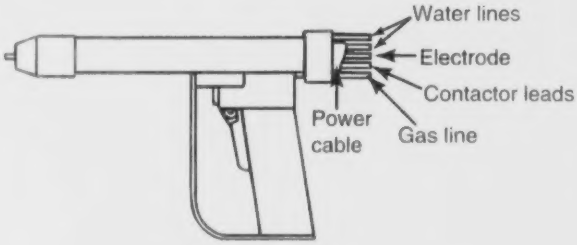
Courtesy of Lincoln Electric Company.

c. Air-cooled and water-cooled guns are used for the gas-shielded process with air-cooled guns generally used for operations up to 600 amps, and water-cooled guns for operations over 600 amps.

Figure 6


Power cable
Contactor leads
Electrode
Gas line

Air-cooled gun

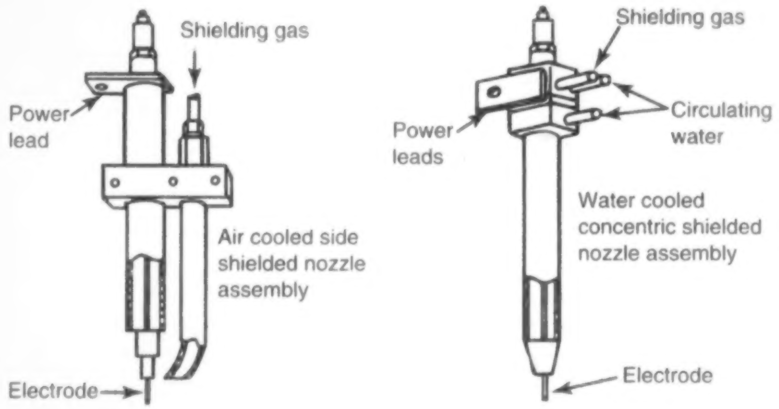

Water lines
Electrode
Contactor leads
Power cable
Gas line

Water-cooled gun

Courtesy of Lincoln Electric Company.

d. Air-cooled guns are used for automatic processes where side shielding is required, and water-cooled guns are used for automatic processes where concentric shielding is required.

Figure 7


Shielding gas
Power lead
Air cooled side shielded nozzle assembly
Electrode
Shielding gas
Circulating water
Power leads
Water cooled concentric shielded nozzle assembly
Electrode

Air-cooled automatic gun

Water-cooled automatic gun

Courtesy of Lincoln Electric Company.

Objective 8

Classifications for FCAW electrode wires

a. As with other AWS electrode classifications, the introductory "E" means electrode.

b. The second two digits indicate the tensile strength and welding position.

c. The "T" indicates the tubular construction of the flux-cored wire.

d. Final numbers or number-letter combinations indicate any special chemical composition of the wire.

Example: In an E70T-4, the E means electrode, the 7 indicates the tensile strength of 70,000 psi, the 0 means the electrode may be used in the flat or horizontal positions, the T means it is tubular, and the 4 indicates the chemical composition of the electrode.

e. The "T" and following number are also used to indicate whether or not the electrode is to be used as self-shielded or gas-shielded, and are classified as follows:

- Self-shielded—All T-3, T-4, T-6, T-7, T-8, T-9, and T-10 electrodes are in this class.
- Gas-shielded—All T-1, T-2, and T-5 electrodes are in this class.

Example: The T-3 in the E70T-3 designation indicates a self-shielded electrode.

f. The T-3 and T-6 electrodes are designed for DCEP operations with fast wire-feed speeds and high amperages for high deposition welding.

g. Other T-series electrodes are designed for DCEN with slower wire-feed speeds and lower amperages, but still provide fast travel and good penetration for special applications.

h. Other classifications include T-G which covers multi-pass electrodes not covered under specific classifications, and T-GS which covers single-pass electrodes of the same category.

i. Metal core wires fall under AWS A5.18–93 for classification; however metal core wires are listed under flux-core because they are more commonly listed in cored wire literature.

Note: For typical flux-cored electrode operating variables, refer to Student Supplement 1.

Objective 9

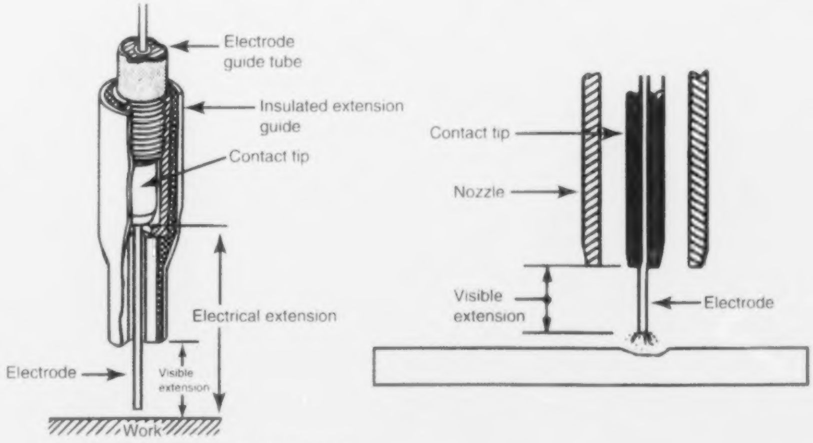
Electrode extension and visible electrode extension

a. Electrode extension is the length of the electrode from the contact tip within the nozzle to the workpiece.

b. Visible electrode extension is the length of the electrode that can actually be seen between the end of the nozzle and the workpiece.

Note: Electrode extension is sometimes referred to as electrode stickout, and visible electrode extension is sometimes called visible stickout. When the contact tip and the end of the nozzle terminate at the same point, electrode extension and visible electrode extension are the same.

Figure 8


Electrode guide tube
Insulated extension guide
Contact tip
Electrical extension
Electrode
Visible extension
Work
Contact tip
Nozzle
Visible extension
Electrode

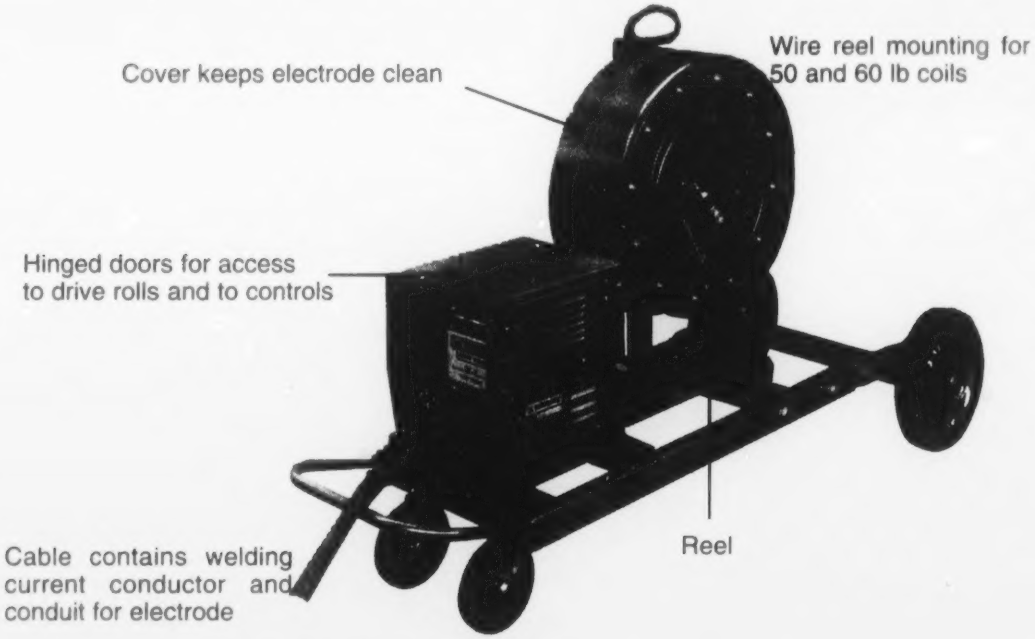
Courtesy of Lincoln Electric Company.

Objective 10

Basic types of flux-cored wire feeders

a. **Integrated**—Drive-roll and control units are attached to the wire reel housing and the entire unit is mounted on a mobile dolly so the equipment can be moved close to the work area.

Figure 9


Cover keeps electrode clean
Wire reel mounting for 50 and 60 lb coils
Hinged doors for access to drive rolls and to controls
Reel
Cable contains welding current conductor and conduit for electrode

Courtesy of Lincoln Electric Company.

b. **Remote**—Drive-roll and control unit are detached from the wire reel housing so longer work-to-electrode distances can be used and the control unit can be moved closer to confined work area.

Objective 11

Guidelines for using drive rolls and guide tubes

a. Drive rolls and guide tubes for wire feeders have the wire sizes for which they are designed stenciled on them; use only the wires that are specified.

b. Clean drive rolls and guide tubes after each roll of wire electrode is used.

c. Remove accumulated dirt and shavings with a wire brush, but do not use a solvent to clean drive rolls.

d. Some worn drive rolls can be reversed, but when drive rolls are badly worn, replace them.

e. When drive rolls slip while being fed into the cable, check to see if the end of the wire has been improperly prepared or check for shavings that may build up in the cable.

Information Sheet

Objective 12

Steps for starting an arc with the semiautomatic process

a. Inch the electrode out beyond the nozzle to just short of the visible electrode extension recommended for the electrode size and guide tip.

b. Cut the end of the wire.

c. Position the tip of the electrode just off or just barely touching the base metal.

d. Squeeze the trigger to start the arc, but do not push the electrode into the joint as it starts to burn away.

e. Allow the arc to fully establish itself, then slowly pull the gun back until the recommended electrode extension is established.

f. Even when a long electrode extension is desired, start with about $^{1}/_{2}$″ of visible electrode extension, establish the arc as outlined, then increase the stickout to the desired length.

Objective 13

Operating variables with flux-cored electrode wires

a. Arc voltage—When all other variables are held constant, arc voltage variations will have these effects:

- High arc voltage will produce a wider and flatter bead.
- Excessive arc voltage will tend to produce porosity.
- Low voltage tends to produce a convex, ropey bead.
- Extremely low voltage will cause the wire to stub on the plate or cause the wire to pierce the plate, strike the joint bottom, and push the gun up.

b. Current—When all other variables are held constant, current variations will have these effects:

- Increasing current will increase melt-off and deposition rate.
- Excessive current will produce a convex bead that looks bad and wastes metal.
- Low current will result in reduced penetration.

c. Travel speed—When all other variables are held constant, travel speed variations will have these effects:

- Excessive travel speed makes the bead concave with uneven edges.
- Too slow a travel speed produces slag inclusions and a rough, uneven bead.

d. Electrode extension—When all other variables are held constant, electrode extension variations will have these effects:

- Increased extension decreases current and decreased extension increases current.
- Increased extension lowers voltage across the arc, the lower arc voltage makes the bead more convex, and the tendency for porosity is reduced.
- Short extension gives greater penetration than long extension.

Objective 14

Guidelines for preparing FCAW applications

a. Clean the joint of scale, rust, paint, oil, grease, and moisture, because clean surfaces help reduce porosity and make possible the faster welding speeds important for the FCAW process.

b. When making tack welds, you should use the same electrode recommended for the application.

c. Clamp the work cable to the workpiece so that there is good metal-to-metal contact.

Note: Good grounding is essential because machine meters may indicate proper voltage when a bad ground is causing convex or ropey beads that are typically the result of low voltage.

d. Try different locations for the ground clamp to obtain the best weld quality.

e. Never use undersized or badly worn cables.

Objective 15

Guidelines for semiautomatic FCAW

a. Obtain a good bead shape by using the highest voltage possible without causing porosity.

b. To maintain a good bead shape, always increase arc voltage when you increase current.

c. Remember that travel speed is almost always faster with self-shielded flux-cored electrodes than with SMAW electrodes because of the high deposition rate.

Note: Beginners with the semiautomatic FCAW process almost always use a travel speed that is too slow.

Objective 16

Safety requirements for FCAW

a. Use personal safety clothing and equipment when working with FCAW equipment.

b. Follow procedures for safely operating machines and electrical components at all times.

c. When working with flux-cored wires that produce excessive smoke and fumes, use a welding gun with a smoke removal attachment.

d. Sparks generated by the FCAW process can be excessive and erratic, so screen the welding area from nearby workers and people passing by.

Objective 17

Guidelines for troubleshooting FCAW problems

a. Inspect all welds for the smooth, uniform appearance that FCAW should deliver.

b. Try to isolate the problem to a logical source.

Example: Porosity can often be caused by insufficient flux in the core of the electrode wire, but porosity can also be caused by excessive voltage and excessive travel speed, so work with a voltage or travel speed adjustment before changing out the electrode wire.

c. As a beginner, always consider that weld discontinuities frequently result from bad practices or procedures.

d. Follow manufacturer's procedures for troubleshooting all electrical devices.

Note: For extended troubleshooting guidelines as outlined by the American Welding Society, see Student Supplement 4.

Student Supplement 1—Typical Operating Variables for Flux-Cored Electrodes

AWS Class	Size	Polarity	ESO	Normal Arc Voltage (Volts)	Settings Wire Feed Speed (in/min)	Approximate Current (amps)	Deposition Rate (lbs/hr)
E71T-GS	.068″	DC(–)	1/2″	21	185 Max.	360	8.9
				19	125	270	6.2
				17	80 Opt.	185	4.0
				15	60	140	3.0
E71T-7	.068″	DC(–)	1″	23	210 Max.	300	8.7
				21.5	155	250	6.2
				20.5	110 Opt.	200	4.2
				19	70	150	2.4
				18	55	100	1.7
E71T-7	5/64″	DC(–)	1″	24	230 Max.	400	13.2
				23	185	350	10.5
				22	145 Opt.	300	8.0
				21	110	250	5.8
				20	75	200	3.7
				19	55	150	2.4
E71T-8	3/32″	DC(–)		22	120 Max.	350	8.6
				21	110	330	7.8
				20	95 Opt.	300	6.7
				16	50	190	3.6

Student Supplement 2—FCAW-GS Electrodes

Purpose of Core Elements

1. Allows for deep penetration and high deposition rates, even out of position.
2. Gains mechanical and metallurgical properties.
3. Refines the metal in the molten pool with deoxidizers and denitrifiers.
4. Provides a slag coverage to:
   a. Protect the weld.
   b. Shape the weld bead.
   c. Hold the weld in place for out of position welding.

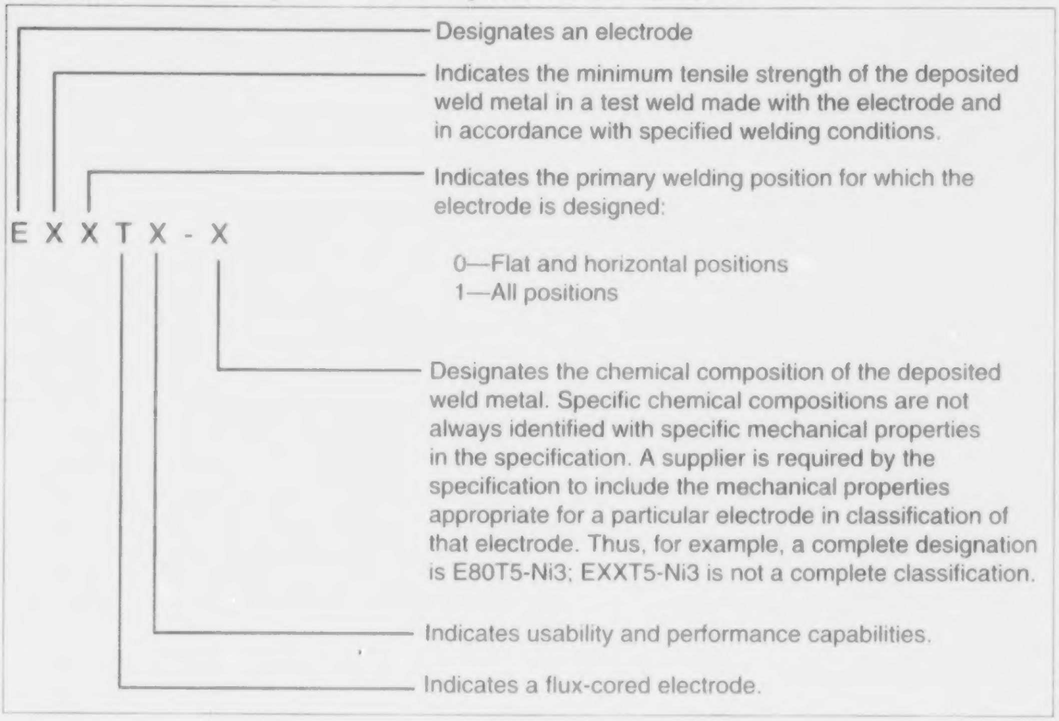
Common Core Elements and Their Functions

Core Elements	Function
Aluminum	Deoxidize and denitrify
Calcium	Provide shielding and form slag
Carbon	Increase hardness and strength
Manganese	Deoxidize and increase strength
Molybdenum	Increase hardness and strength
Nickel	Improve hardness, strength, toughness, and corrosion resistance
Potassium	Stabilize the arc and form slag
Silicon	Deoxidize and form slag
Sodium	Stabilize arc and form slag
Titanium	Deoxidize, denitrify, and form slag

Copyright© 2000 Lincoln Global Inc.

Student Supplement 3—AWS Classifications for FCAW Electrodes

Table 1—Identification system for low alloy steel FCAW electrodes



Designates an electrode

Indicates the minimum tensile strength of the deposited weld metal in a test weld made with the electrode and in accordance with specified welding conditions.

Indicates the primary welding position for which the electrode is designed:

0—Flat and horizontal positions
1—All positions

Designates the chemical composition of the deposited weld metal. Specific chemical compositions are not always identified with specific mechanical properties in the specification. A supplier is required by the specification to include the mechanical properties appropriate for a particular electrode in classification of that electrode. Thus, for example, a complete designation is E80T5-Ni3; EXXT5-Ni3 is not a complete classification.

Indicates usability and performance capabilities.

Indicates a flux-cored electrode.

Table 2—Shielding and polarity requirements for mild steel FCAW electrodes

AWS Classification	External Shielding Medium	Current and Polarity
EXTT-1 (Multiple-pass)	CO_2	dc, electrode positive
EXXT-2 (Single-pass)	CO_2	dc, electrode positive
EXXT-3 (Single-pass)	None	dc, electrode positive
EXXT-4 (Multiple-pass)	None	dc, electrode positive
EXXT-5 (Multiple-pass)	CO_2	dc, electrode positive
EXXT-6 (Multiple-pass)	None	dc, electrode positive
EXXT-7 (Multiple-pass)	None	dc, electrode negative
EXXT-8 (Multiple-pass)	None	dc, electrode negative
EXXT-10 (Single-pass)	None	dc, electrode negative
EXXT-11 (Multiple-pass)	None	dc, electrode negative
EXXT-G (Multiple-pass)	*	*
EXXT-GS (Single-pass)	*	*

*As agreed upon between supplier and user.

Courtesy of the American Welding Society.

Student Supplement 4—FCAW Troubleshooting

Problem	Possible Cause	Corrective Action
Porosity	Low gas flow	Increase gas flowmeter setting clean spatter clogged nozzle
	High gas flow	Decrease to eliminate turbulence
	Excessive wind drafts	Shield weld zone from draft/wind
	Contaminated gas	Check gas source Check for leak in hoses/fittings
	Contaminated base metal	Clean weld joint faces
	Contaminated filler wire	Remove drawing compound on wire Clean oil from rollers Avoid shop dirt Rebake filler wire
	Insufficient flux in core	Change electrode
	Excessive voltage	Reset voltage
	Excess electrode extension	Reset electrode extension and balance current
	Insufficient electrode extension (self-shielded electrodes)	Reset electrode extension and balance current
	Excessive travel speed	Adjust speed
Incomplete fusion or penetration	Improper manipulation	Direct electrode to the joint root
	Improper parameters	Increase current Reduce travel speed Decrease electrode extension Reduce wire size Increase travel speed (self-shielded electrodes)
	Improper joint design	Increase root opening Reduce root face
Cracking	Excessive joint restraint	Reduce restraint Preheat Use more ductile weld metal Employ peening
	Improper electrode Insufficient deoxidizers or inconsistent flux fill in core	Check formulation and content of flux
Electrode feeding	Excessive contact tip wear	Reduce drive roll pressure
	Melted or stuck contact tip	Reduce voltage Adjust backburn control Replace worn liner
	Dirty wire conduit in cable	Change conduit liner Clean out with compressed air

Courtesy of the American Welding Society.

Gas Metal Arc Welding and Flux-Cored Arc Welding

THIRD EDITION

MAVCC

Student Workbook

CE081768

1-014933

6004

BEST COPY AVAILABLE

Gas Metal Arc Welding and Flux-Cored Arc Welding

Third Edition

Student Workbook

Written by

Clarence Fortney
Mike Gregory
and
Larry New

Revised by

John Knapp
and
Eddie Harper

Project coordinated by

Cheryl Barr

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

©2001

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

01-014933 600442

©2001 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

Cover art courtesy of Lincoln Electric Company.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Workbook Contents

Unit 1

Assignment Sheet

1—Solve Problems Concerning GMAW Safety 1

Unit 2

Job Sheets

1—Set Up Wire on a GMAW Wire Feeder 3
2—Set Up a Flow Meter and Regulator for a GMAW Shielding Gas 7
3—Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel 9
4—Prepare Mild Steel for GMAW 11
5—Use Short-Circuit Transfer to Lay Stringer Beads and Build a Pad on Mild Steel in the Flat Position 13
6—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 17
7—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 21
8—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 25
9—Perform a Guided-Bend Test on a Welded V-Groove Butt Joint 29
10—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 35
11—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 39
12—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . . . 43
13—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position 47
14—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position 51
15—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position 55
16—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position 61
17—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position 65
18—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position . . . 69
19—Set Up GMAW Equipment for Spray Transfer on Mild Steel . . . 75
20—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position 79
21—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position 83
22—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position 87
23—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 91

Workbook Contents

24—Use Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position ... 95
25—Set Up GMAW Equipment for Spray Transfer on Aluminum ... 99
26—Prepare Aluminum for GMAW ... 103
27—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position ... 105
28—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position ... 109
29—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position ... 113
30—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position ... 117
31—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Up Position ... 121
32—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position ... 125
33—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position ... 129
34—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position ... 133
35—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position ... 137
36—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position ... 141
37—Set Up GMAW-P Equipment for Pulsed-Spray Transfer on Mild Steel ... 145
38—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position ... 147
39—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 151
40—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position ... 155
41—Set Up STT Equipment for Surface Tension Transfer on Mild Steel ... 159
42—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position ... 161
43—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position . 165
44—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position ... 169

Unit 3 Job Sheets

1—Set Up or Replace Wire on a Flux-Cored Wire Feeder ... 175
2—Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding ... 179
3—Prepare Mild Steel for FCAW ... 181
4—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position ... 183
5—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position ... 187
6—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position ... 191

7—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position 195
8—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position 199
9—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position 203
10—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position 207
11—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position 211
12—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position 215
13—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position 219
14—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position 223
15—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position 227

Objective 17

Assignment Sheet 1—Solve Problems Concerning GMAW Safety

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Problems were recognized	______
• Solutions are accurate	______

Basic Skills

Reading Writing Critical Thinking Employability

Directions

Read the following statements carefully. Write a brief statement recommending a specific solution if a safety violation is presented.

1. A fellow student is attempting to repair a malfunctioning gun while the welding machine is still on. Is there a problem? ______________
   Solution: ______________________________
2. You are working with a welding machine that has a Class III NEMA rating and realize that you have been welding for almost five minutes without stopping. Is there a problem? ______________
   Solution: ______________________________
3. A coworker is using an oily rag to clean a welding cable. Is there a problem? ______________
   Solution: ______________________________
4. It is hot and you are sweating and decide that it's safe to pull up your sleeves to be a little more comfortable, and you are certain that no sparks will hit you so you feel safe. Is there a problem? ______________
   Solution: ______________________________
5. You notice a coworker reloading a coil of electrode wire without wearing safety glasses. Is there a problem? ______________
   Solution: ______________________________

Objective 34

Job Sheet 1—Set Up Wire on a GMAW Wire Feeder

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment safety	______
• Proper removal of old spool	______
• New spool set up to feed from bottom or top	______
• Wire properly fed through roller	______
• Wire-inch control properly used	______
• Pinch test used to test wire tension	______
• Wire properly prepared for welding activity	______

Basic Skills

Reading

Critical Thinking

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- GMAW machine and accessories
- Personal safety clothing and equipment
- GMAW wire spool or coil
- Screwdriver
- Adjustable wrench
- Wire-cutting pliers
- Fine-cut file
- Nozzle spray or gel

Procedure

☐ 1. Shut off input power to the power supply and wire feeder.

☐ 2. Get a firm hold on the wire near the pressure rollers, if you are replacing a partial spool.

☐ 3. Cut the wire with wire-cutting pliers near the pressure rollers, or relieve pressure rollers and manually rewind spool of wire unless cold wire feed reverse capability is available.

☐ 4. Locate the small-diameter hole on the outside edge of the spool, put the end of the cut wire into it, and tie the loose end.

☐ 5. Remove the nozzle from the GMAW gun.

☐ 6. Press the gun trigger switch and run the cut wire past the pressure rollers, and then release the gun trigger switch.

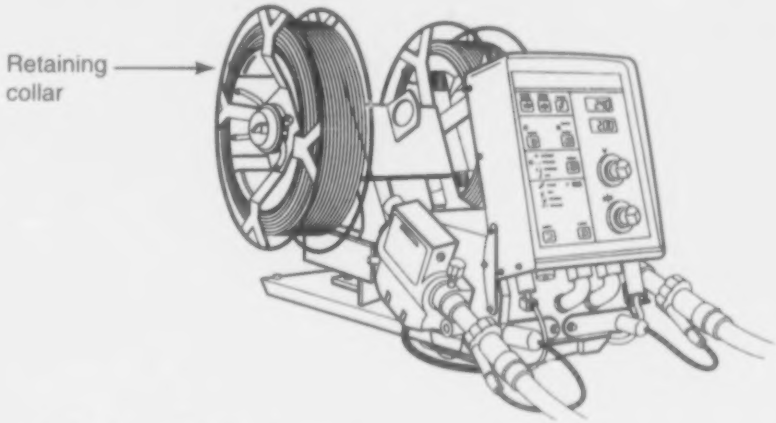
☐ 7. Pull the remaining wire through the cable and dispose of it, if you are replacing a partial or empty spool.

☐ 8. Remove the contact tip.

☐ 9. Remove the retaining collar that holds the spool in place.

Note: Different manufacturers of GMAW equipment use various methods of spool attachment.

Figure 1



Courtesy of Lincoln Electric Company.

☐ 10. Remove the empty or partially used spool from the spindle and store in proper location.

Note: The following procedures are for initial setup or for wire replacement.

☐ 11. Locate the end of the wire on the new spool and position the new spool so that wire will feed from the bottom (or top of wire feeder if so situated) of the spool into the wire feeder.

Caution: Do not remove the free end of the wire from the retaining hole where it is secured or you will have wire all over the place.

☐ 12. Place the new spool of wire onto the spindle and make sure the drag brake pin slips into the proper hole.

☐ 13. Place the retaining collar back on the spindle and force it tightly against the reel.

☐ 14. Locate the end of the wire on the spool, free it from the retaining hold, and clip the end of the wire.

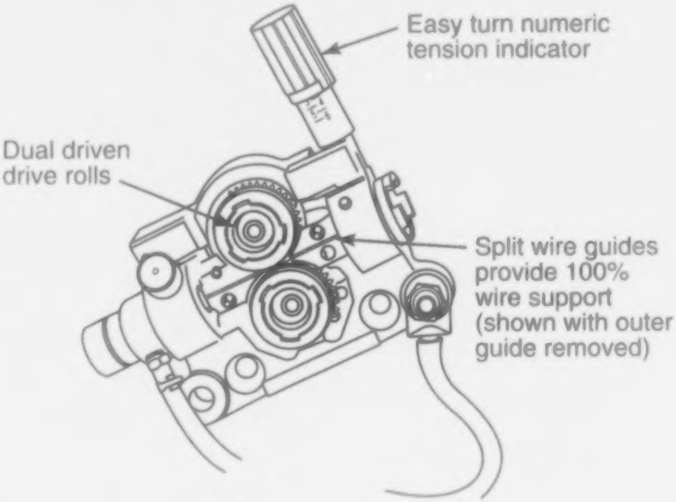
> **Caution:** Hang on to the free end of the wire firmly throughout this procedure.

☐ 15. Use a file to smooth the sharp end of the wire, or clip the wire at an angle for easy feeding.

☐ 16. Release pressure on the top drive rollers by loosening tension indicator, then raise the top roller.

☐ 17. Guide the wire through the split wire guide system and use both hands to push and pull the wire across the bottom drive roll and through the other side of the split wire guide system.

Figure 2


Easy turn numeric tension indicator
Dual driven drive rolls
Split wire guides provide 100% wire support (shown with outer guide removed)

Courtesy of Lincoln Electric Company.

☐ 18. Continue pushing and pulling the wire until it moves into and through the wire feed power assembly 2″ to 3″.

> **Caution:** Do not force the wire into the wire feed assembly, just work it back and forth until it fits smoothly.

☐ 19. Bring top feed roll down so that the wire lies in the groove between both the rollers.

☐ 20. Use pressure adjusting screw to provide operating pressure between the bottom and top rollers.

> **Caution:** Do not overtighten the adjusting screw and cause the wire to flatten out.

☐ 21. Turn power supply on and wire feed power on.

☐ 22. Position gun so that the cable conduit between the wire feeder and gun is straight.

Note: Use the wire-inch for the following adjustment because it will help keep from shorting out the gas diffuser and wasting expensive shielding gas. If the machine does not have a wire-inch, turn off the gas supply and avoid grounding out the bare gas diffuser.

☐ 23. Turn the wire-inch on or set wire feed control to half speed and feed the wire through the cable conduit to the gun while testing tension on the feed roller with the following procedures:

  ☐ a. Pinch the wire with finger pressure just ahead of the insulated input guide.

  ☐ b. If a slight pinching pressure will stop the wire from feeding through, the tension is probably all right.

  ☐ c. If a slight pinching pressure will not stop the wire from feeding through, the tension is probably too much.

☐ 24. Turn off power supply and wire feed supply, then replace the contact tip required for the size wire you are using, then snug the contact tip with pliers carefully. Clip wire to 1/4" to 3/8" stickout.

☐ 25. Replace nozzle over contact tip. Drive rolls and contact tip must match the diameter of the wire.

☐ 26. Have your instructor check your work.

Note: The procedure for replacing a coil-type wire reel is essentially the same as a spool-type reel except that the coil-type reel has a spring-loaded device to secure and release it so that the reel separates into two halves in order for a replacement coil to be installed.

☐ 27. Adjust machine for specified welding activity.

☐ 28. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 35

Job Sheet 2—Set Up a Flow Meter and Regulator for a GMAW Shielding Gas

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Cylinder safety	______
• Regulator setup	______
• Flow meter setup	______
• Cfh adjustment	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- GMAW machine and accessories
- Selected shielding gas cylinder
- Flow meter and regulator
- Adjustable wrench or 1 1/8″ open-end wrench
- Safety glasses and personal safety clothing

Procedure

☐ 1. Make sure the gas cylinder is safely secured in an upright position.

☐ 2. Remove the cylinder cap.

☐ 3. Crack the cylinder valve slightly to clear the cylinder valve fitting.

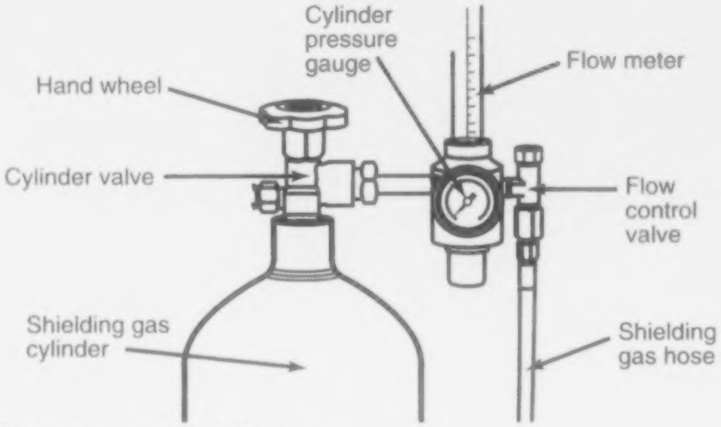
☐ 4. Attach the flow meter regulator to the cylinder valve.

☐ 5. Tighten the regulator fitting nut with a wrench, but do not overtighten.

Note: When using 100% CO_2, insert a nonmetallic washer inside the regulator connection to prevent the regulator from leaking.

☐ 6. Make sure the flow meter adjusting valve is off, and if it is not, turn it clockwise until it is tight.

Figure 1


Cylinder pressure gauge
Flow meter
Hand wheel
Cylinder valve
Flow control valve
Shielding gas cylinder
Shielding gas hose

Courtesy of Lincoln Electric Company.

☐ 7. Attach gas hose to flow meter and wire feeder.

☐ 8. Open the gas cylinder valve all the way so that it will back seat against the top of the valve.

☐ 9. Set up and turn on the GMAW machine.

☐ 10. Turn wire feed power on, if applicable.

☐ 11. Turn the wire feed as low as it will go and press the gun trigger switch or use gas purge.

☐ 12. Turn the flow meter adjusting screw counterclockwise to make adjustment for the desired Cfh. Set Cfh between 20 and 40 depending on instructor preference.

☐ 13. Use the very top of the ball or middle depending on manufacturer's calibration as the reference point for adjusting Cfh.

☐ 14. Release gun trigger switch or gas purge.

☐ 15. Have your instructor check your work.

☐ 16. Shut down and secure equipment.

☐ 17. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 36

Job Sheet 3—Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Flow meter and regulator setup	______
• Amp/lpm adjustment	______
• Proper electrode extension	______
• Test bead evaluation	______
• Proper shut down procedure	______

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- GMAW machine and accessories
- Selected shielding gas
- Selected wire
- Personal safety clothing and safety glasses
- Adjustable wrench
- Selected wire or stainless steel

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas and adjust the flow rate as previously outlined.

☐ 2. Attach ground clamps to the workpiece.

☐ 3. Turn the machine on.

☐ 4. Turn the wire feed power on, if applicable.

☐ 5. Adjust voltage and wire feed speed to approximate settings for wire size and plate thickness as directed by your instructor.

☐ 6. Place a piece of scrap metal on the work table.

☐ 7. Place the nozzle of the gun on the piece of scrap metal so the correct electrode extension can be determined and maintained.

☐ 8. Press trigger and run test bead. Release trigger to break arc.

☐ 9. Make adjustments as needed to correct voltage and amperage by performing a series of test welds. Adjust parameters starting with amperage, then voltage.

☐ 10. Inspect your test bead for good penetration, good fusion, and uniform width with minimum spatter.

☐ 11. Have your instructor check your work.

☐ 12. Set wire speed feed to zero if no gas purge switch is available.

☐ 13. Turn off gas supply.

☐ 14. Depress gun trigger to relieve shielding gas pressure, or depress gas purge switch.

☐ 15. Allow ball in flow meter to return to zero. Close the flow meter finger tight.

☐ 16. Turn off feed control power switch, if applicable.

☐ 17. Turn off welding machine power supply.

☐ 18. Store gun, cable assembly, and ground clamp in proper storage.

☐ 19. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

Objective 37

Job Sheet 4—Prepare Mild Steel for GMAW

Name ______________________ Attempt Number ________

Date ______________ ________ Overall Rating ________

Evaluation Criteria	Rating
• Safe use of proper tools	______
• Workpiece preparation	______
• Joint preparation	______

Basic Skills

Reading

Critical Thinking

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Mild steel as selected by instructor
- Joint design as specified by instructor
- Portable grinder and sanding equipment
- Pliers and clamps
- Clean shop rags
- Wire brush
- Personal safety clothing and safety glasses

Procedure

☐ 1. Secure the workpiece with pliers or clamps.

☐ 2. Remove mill scale, rust, dirt, and paint from all surfaces with a portable sander.

☐ 3. Grind edges of joints to specifications.

☐ 4. Wire brush, if required.

☐ 5. Have your instructor check your work.

☐ 6. Check in tools and materials and clean area.

Evaluator's Comments: ________________________________

____

____

Objective 38

Job Sheet 5—Use Short-Circuit Transfer to Lay Stringer Beads and Build a Pad on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Cleaning	______
• Inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

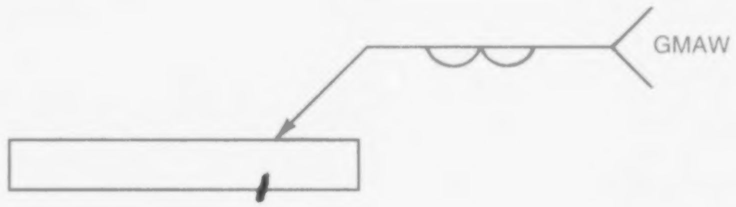
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Mild steel as selected by instructor
- Wire-cutting pliers and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting
5. Shielding gas/flow rate: Per instructor
6. Electrical: DCEP
7. Position: Flat
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

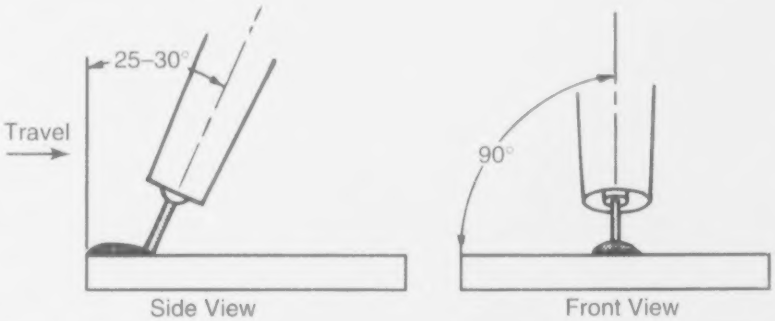
☐ 2. Complete equipment setup as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Position plate on work table.

☐ 5. Move gun down to plate and check gun angle and electrode extension.

Figure 2



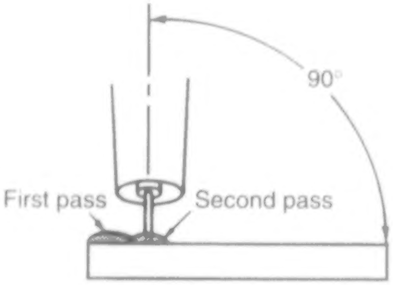
☐ 6. Squeeze gun trigger and use a push or pull technique to lay the bead from left to right if right-handed, and right to left if left-handed.

Note: The nozzles for GMAW guns are large enough that a good view of the weld zone will require that you position yourself so you can see to maintain the correct gun angle and electrode extension.

☐ 7. Weld the full length of the plate and crater and fill to complete the bead.

- ☐ 8. Release gun trigger.
- ☐ 9. Place gun in a safe place.
- ☐ 10. Clean to specifications.
- ☐ 11. Inspect for good penetration and fusion, uniform bead width and appearance, and defects such as excessive spatter and undercutting.
- ☐ 12. Have your instructor check your work.
- ☐ 13. Continue making practice beads as directed by your instructor.
- ☐ 14. Inspect all beads.
- ☐ 15. Have your instructor check your work.
- ☐ 16. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.
- ☐ 17. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated (about $^1/_2$ its width).

Figure 3



Front View

- ☐ 18. Weld additional beads until plate is covered. You may have to cool the plate as you advance.
- ☐ 19. Maintain proper overlap to produce pad of weld beads with a flat surface.
- ☐ 20. Clean and inspect each bead. Continue to practice as directed by your instructor.
- ☐ 21. Have your instructor check your finished pad.

☐ 22. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 39

Job Sheet 6—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

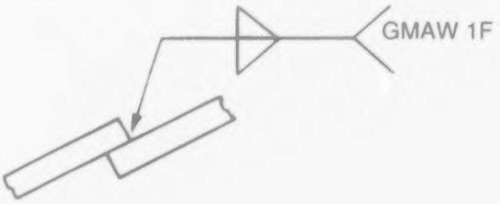
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Mild steel as selected by instructor
- Wire-cutting pliers and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

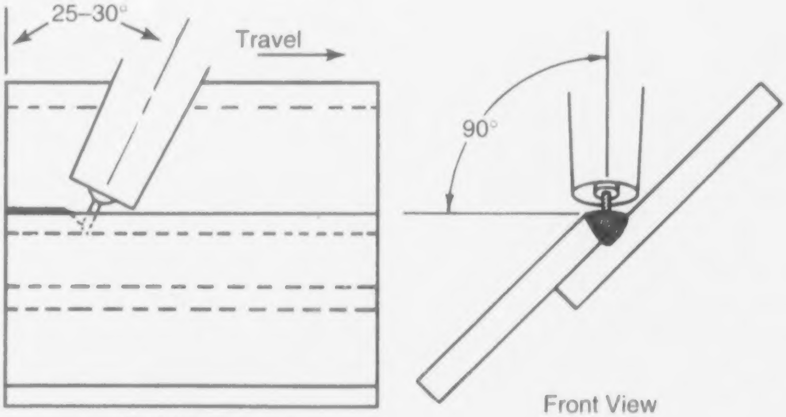
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates at a 45° angle.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to the end of the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with a wire brush as specified.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 40

Job Sheet 7—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

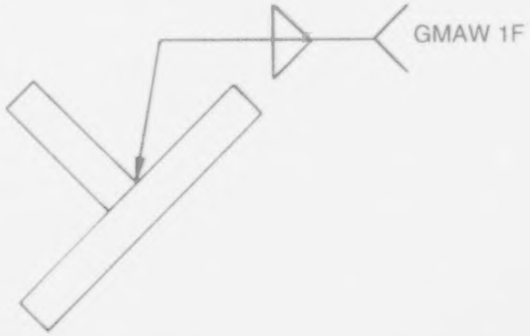
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Mild steel as selected by instructor
- Wire-cutting pliers and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

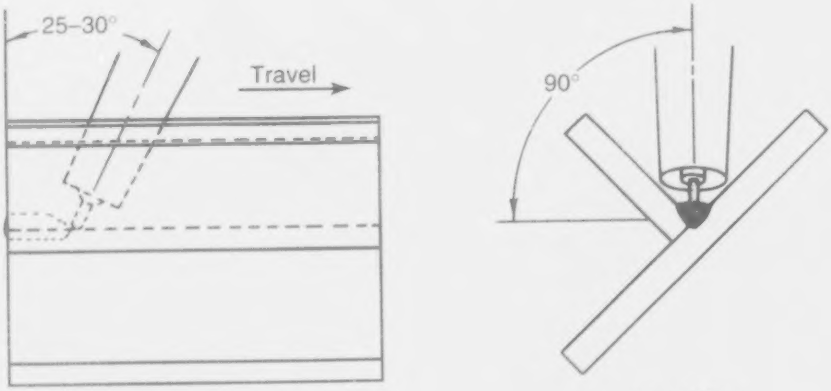
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates at a 45° angle.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Deposit root pass using slight weaving motion. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

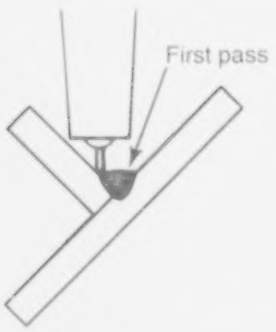
☐ 11. Clean the joint with wire brush as required.

☐ 12. Inspect joint visually.

☐ 13. Check electrode extension for start of second bead, and trim as required, but do not arc excess wire off on the side of the work table. The weld bead should overlap root pass by $^1/_2$ to $^2/_3$.

☐ 14. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.

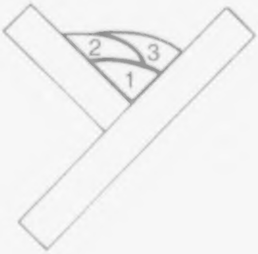
Figure 3



☐ 15. Pull the trigger and complete second bead.

☐ 16. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal. The weld bead should have equal leg dimensions and should overlap by $^1/_2$ to $^2/_3$.

Figure 4



☐ 17. Have your instructor check your work.

☐ 18. Continue with additional beads as directed by your instructor.

☐ 19. Have your instructor check your work.

☐ 20. Repeat procedure for the other side of the joint, if required by your instructor.

☐ 21. Have your instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 41

Job Sheet 8—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding and crater and fill technique, first pass	______
• Welding and crater and fill technique, second pass	______
• Cleaning and inspection	______
• Bend test	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

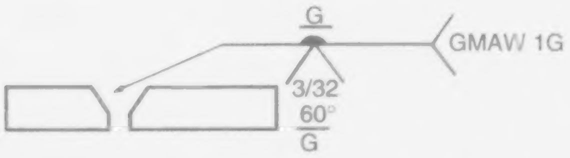
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Bend test machine
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Bend

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a $\frac{1}{16}$" to $\frac{3}{32}$" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for short-circuit transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

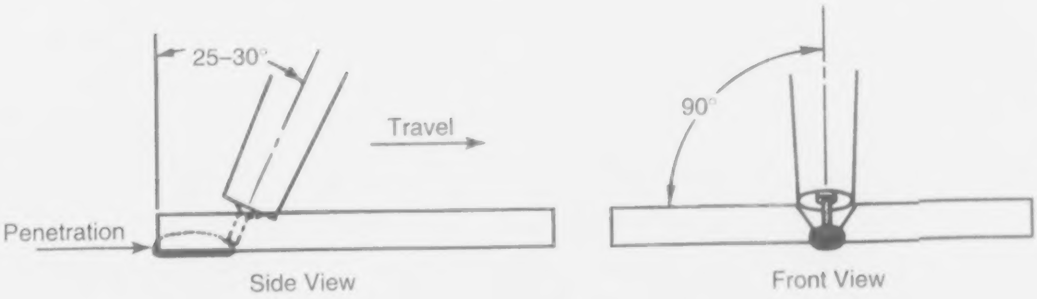
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a $\frac{3}{32}$" opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 10. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be 1/16".

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as required.

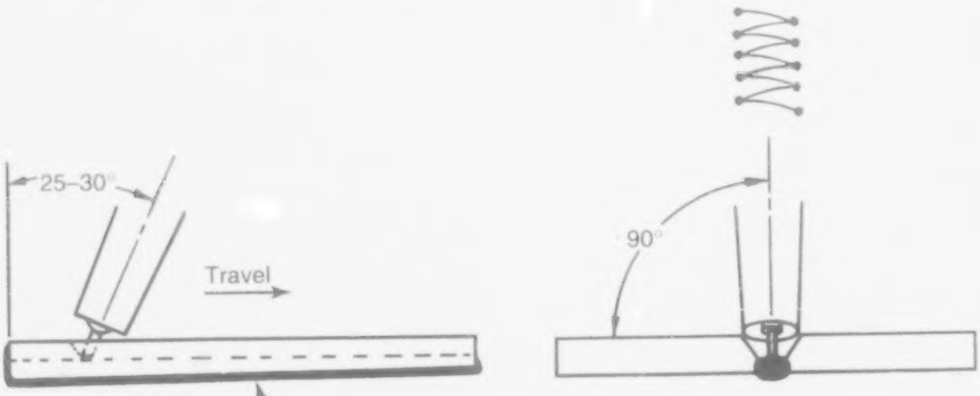
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



Side View

Front View

☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

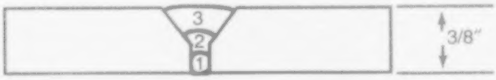
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about 1/16" wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Prepare specimens for bend test as outlined in Job Sheet 9.

☐ 28. Complete bend test.

☐ 29. Have your instructor check your work.

☐ 30. Shut down and secure equipment.

☐ 31. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 42

Job Sheet 9—Perform a Guided-Bend Test on a Welded V-Groove Butt Joint

Name ______________________ Attempt Number ________

Date ________ ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Preparation of test specimen	______
• Root bend procedure	______
• Face bend procedure	______
• Final procedure evaluation	______

Basic Skills

Reading · Critical Thinking · Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Oxyacetylene cutting unit and cutting goggles
- Portable hand grinder
- File and pliers
- Groove weld test plate, 3/8" thickness
- Straightedge and soapstone
- Bend test machine
- Personal safety clothing and safety glasses

Procedure

☐ 1. Check the work area to make sure it is free of flammable materials, and note the location of the nearest fire extinguisher.

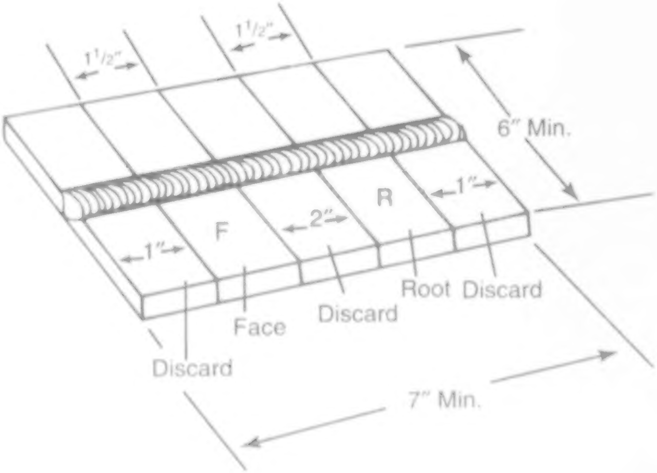
☐ 2. Check the work area for proper ventilation so you can safely use oxyacetylene cutting equipment.

☐ 3. Place the groove weld test plate on a work table in front of you so that measuring and marking can be accomplished accurately.

☐ 4. Use the straightedge and soapstone to mark off bend specimens for a face bend and a root bend.

☐ 5. Mark the face and root bend specimens with an F and an R as indicated in the following illustration.

Figure 1



Note: The face and root bend dimensions shown in the illustration above are in accordance with AWS specifications for welder certification. For training purposes, specimens may be reduced to a total length of 5" with the 1 1/2" specimens cut left and right of center.

☐ 6. Set up oxyacetylene equipment, light and adjust cutting flame and cut the specimens perpendicular to the weld as marked. Discard the two end pieces.

Note: You could use a band saw or other cutting device to cut straps.

☐ 7. Turn off torch and shut down cutting unit.

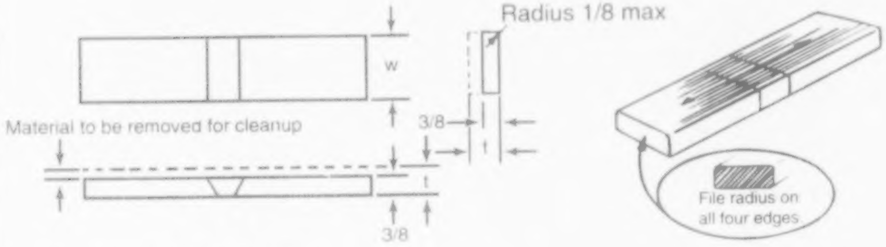
☐ 8. Permit specimens to air cool, but do not quench them in water or they will be unsuitable for testing.

☐ 9. Take cooled specimens one at a time, secure in a vise, and use a portable grinder to grind to the following specifications:

  ☐ a. Face and root bend specimen for a plunger-type tester should be a minimum of 6″ long, 1 1/2″ wide and so ground that both the root and face of the weld are flush with the surface of the specimen. Do not remove base metal.

  Note: For a wraparound-type tester, a longer specimen will probably be required.

Figure 2

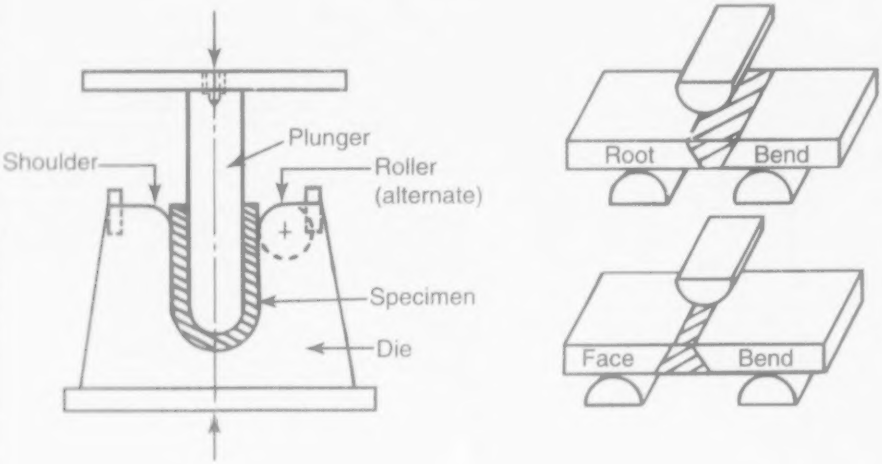

Radius 1/8 max
w
Material to be removed for cleanup
3/8
t
3/8
File radius on all four edges

Courtesy of Lincoln Electric Company

☐ 10. Grind or file the corners of both specimens so that they have a 1/8″ radius.

☐ 11. Take specimens to plunger-type tester and make bends according to the following procedure:

Figure 3



☐ a. Place the face bend specimen on the die member of the fixture with the face of the weld pointing into the die so that the plunger is on the root side of the weld.

☐ b. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

> **Caution:** Always wear safety glasses when conducting bend tests.

☐ c. Release pressure on plunger to release the specimen from the die.

☐ 12. Repeat the testing procedure for the root bend, but reverse the root and face of the weld as you place it on the die.

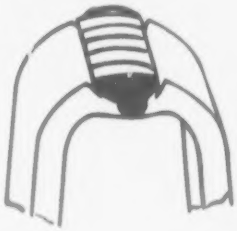
☐ 13. Inspect test specimens according to the following procedure:

☐ a. Examine convex surface of both specimens for cracks or other open defects.

☐ b. Check root bend to determine if weld has complete penetration through the joint.

☐ c. Check face bend to determine if there is complete fusion of the beveled edges with the weld.

Figure 4



☐ 14. Have your instructor check your bend test.

☐ 15. Check in tools and materials and clean area.

Evaluator's Comments: ______________________

____

____

Objective 43

Job Sheet 10—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position

Name ________ ____________________ Attempt Number ________

Date ____________________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

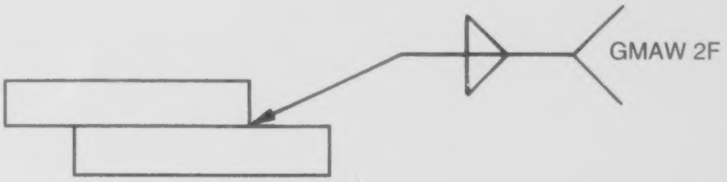
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

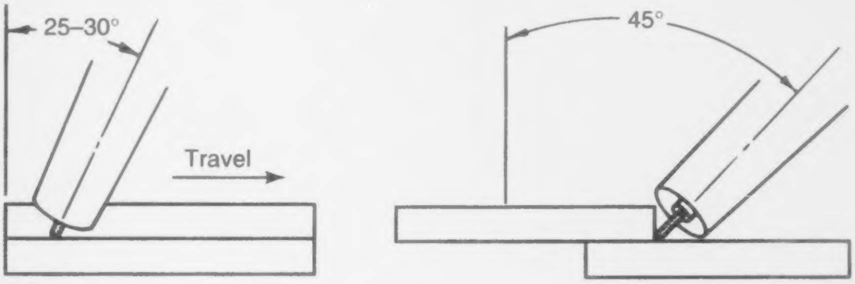
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in correct welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 44

Job Sheet 11—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

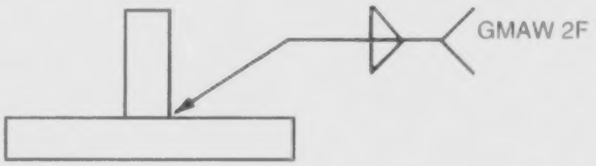
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

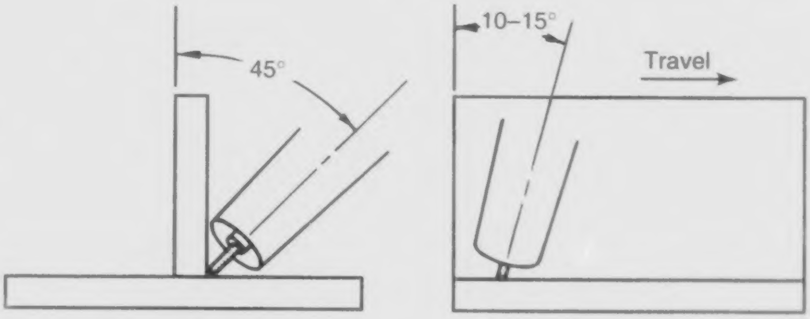
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Deposit root pass using a slight weaving motion. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

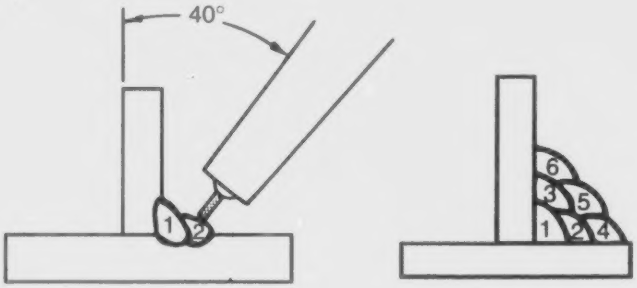
☐ 11. Clean joint with wire brush as required.

☐ 12. Inspect joint visually.

☐ 13. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table. The weld bead should overlap root pass by 1/2 to 2/3.

☐ 14. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.

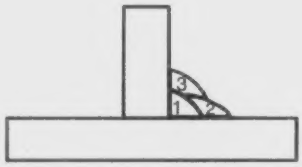
Figure 3



☐ 15. Pull the trigger and complete second bead.

☐ 16. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal. The weld bead should overlap by 1/2 to 2/3. The weld should have equal leg dimensions.

Figure 4



☐ 17. Have instructor check your work.

☐ 18. Continue with additional beads as directed by your instructor.

☐ 19. Have instructor check your work.

☐ 20. Repeat the procedure for the other side of the joint, if directed by your instructor.

☐ 21. Have instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 45

Job Sheet 12—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______
• Bend test	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

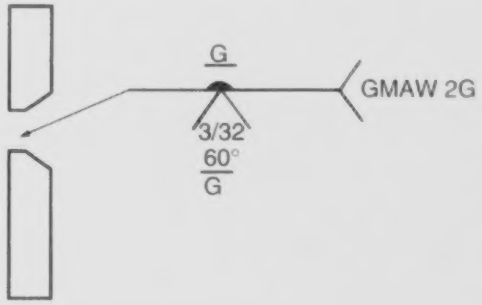
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Bend test machine
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Bend

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a $^{1}/_{16}$″ to $^{3}/_{32}$″ root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for short-circuit transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

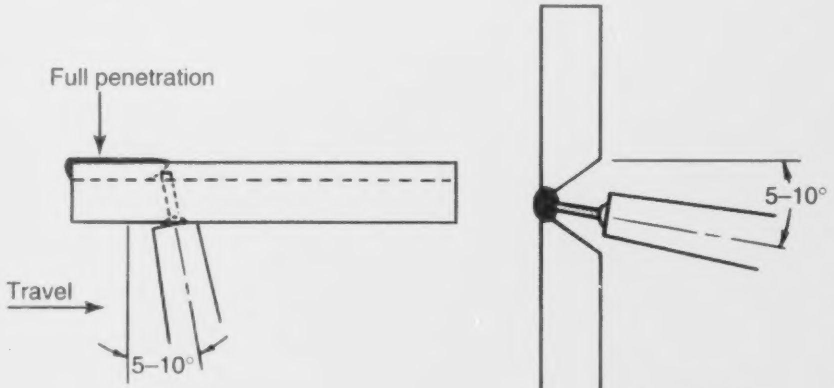
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a $^{3}/_{32}$″ root opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



Top View Front View

☐ 10. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. Stay on leading edge of puddle. Root reinforcement should be 1/16″.

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as required.

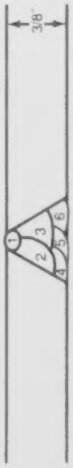
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Overlap root pass by about 1/2 to 2/3.

Figure 3



☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Deposit third weld bead. Use weave or oval motion. Overlap second pass by about 1/2 to 2/3. Make sure you tie into top bevel.

☐ 19. Check electrode extension for start of cap bead, and trim wire as required.

- ☐ 20. Deposit fourth weld bead. Lower toe should penetrate 1/16″ into surface of base metal to ensure complete fusion.
- ☐ 21. Deposit fifth weld bead. Overlap fourth pass by 1/2 to 2/3.
- ☐ 22. Deposit sixth weld bead. Overlap fifth pass by 1/2 to 2/3. Top toe should overlap top edge of joint by about 1/8″ to ensure complete fusion.
- ☐ 23. Clean and inspect cap pass, and put gun in safe place.
- ☐ 24. If you are ready to test, prepare specimens for bend test as previously outlined.
- ☐ 25. Complete bend test.
- ☐ 26. Have your instructor check your work.
- ☐ 27. Shut down and secure equipment.
- ☐ 28. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 46

Job Sheet 13—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	
• Electrical adjustments	
• Electrode extension	
• Welding technique	
• Crater and fill technique	
• Cleaning and inspection	

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

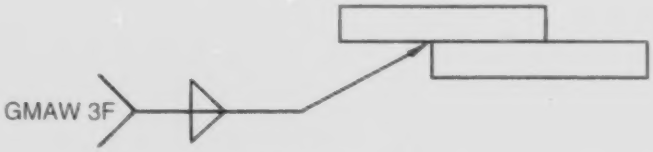
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



Top View

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical
9. Technique: Push
10. Cleaning: Brush
11. Inspection: Visual
12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

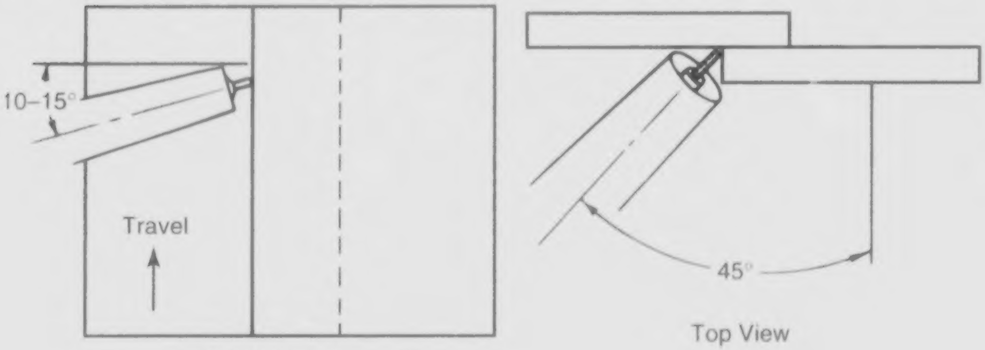
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in vertical welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Front View

Top View

299

☐ 8. Squeeze gun trigger and use push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 47

Job Sheet 14—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

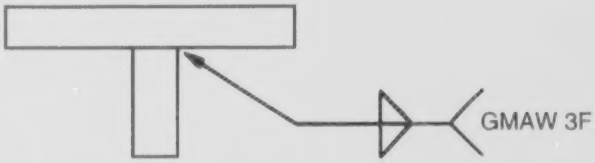
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



Top View

2. Wire: Per instructor

3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical
9. Technique: Push
10. Cleaning: Brush
11. Inspection: Visual
12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

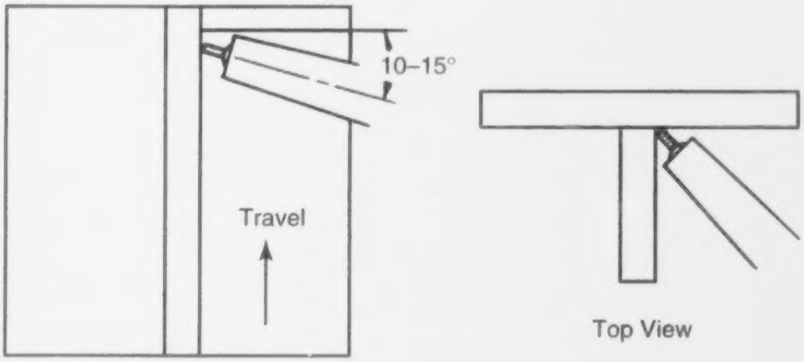
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in vertical welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Front View

Top View

☐ 8. Squeeze gun trigger and use push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Deposit root pass using a slight weaving motion starting at the bottom. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

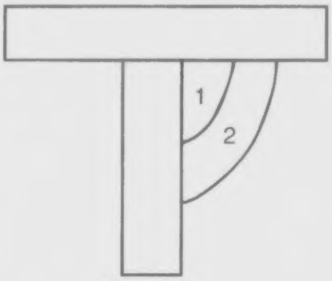
☐ 11. Clean joint with wire brush as required.

☐ 12. Inspect joint visually.

☐ 13. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 14. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated. Use a wider weave motion. Hold sides and move quickly across the middle.

Figure 3



Top View

☐ 15. Pull the trigger and complete second bead. Weld should have equal leg dimensions and should be 1/2" wide.

☐ 16. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 17. Have instructor check your work.

☐ 18. Continue with additional beads as directed by your instructor.

☐ 19. Have instructor check your work.

☐ 20. Repeat the procedure for the other side of the joint, if directed by your instructor.

☐ 21. Have instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

304

Objective 48

Job Sheet 15—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______
• Bend test	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

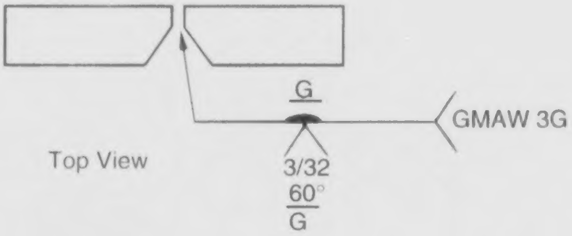
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Bend test machine
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3G
8. Direction of welding: Vertical
9. Technique: Weave
10. Cleaning: Brush
11. Inspection: Visual
12. Testing: Bend

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16" to 3/32" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for short-circuit transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

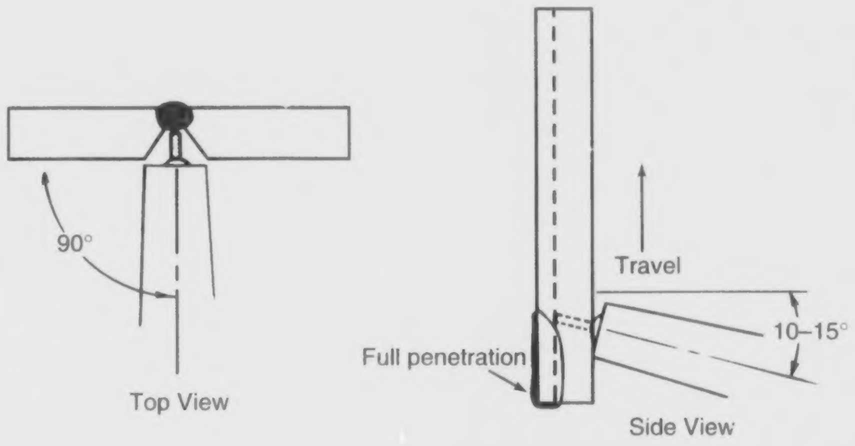
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32" opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 10. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be 1/16″.

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as required.

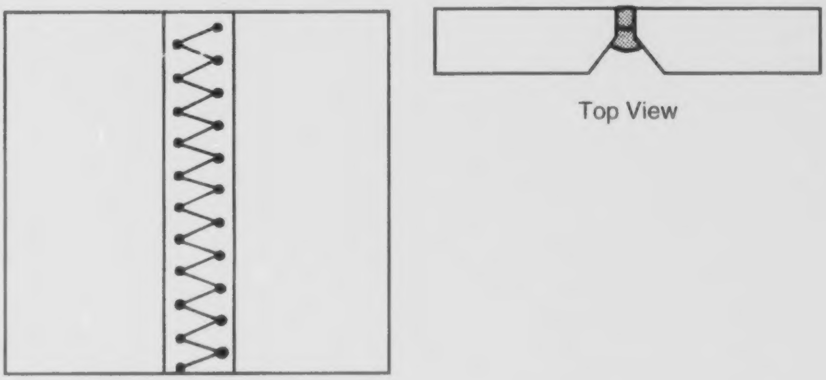
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



Pause at dots.

Top View

☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

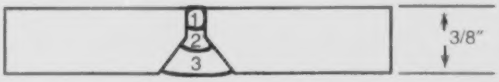
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about 1/16″ wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



Top View

☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Prepare specimens for bend test as previously outlined.

☐ 28. Complete bend test.

☐ 29. Have your instructor check your work.

☐ 30. Shut down and secure equipment.

☐ 31. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 49

Job Sheet 16—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

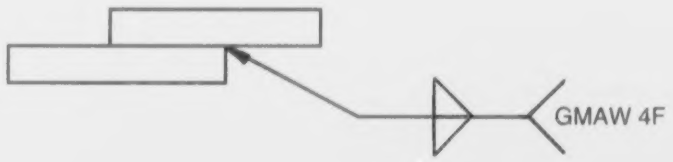
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor

6. Electrical: DCEP

7. Position: 4F

8. Technique: Push or pull

9. Cleaning: Brush

10. Inspection: Visual

11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

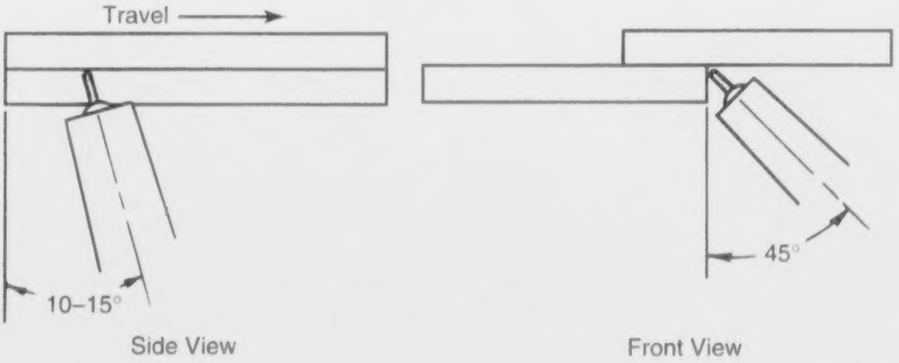
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in overhead welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 9. Crater and fill to end the weld, and weld opposite joint using same procedure.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 50

Job Sheet 17—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Electrical adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

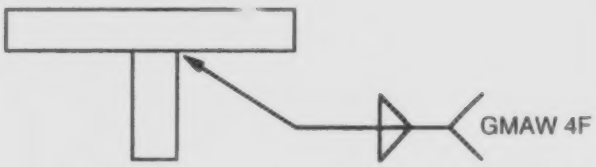
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4F
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

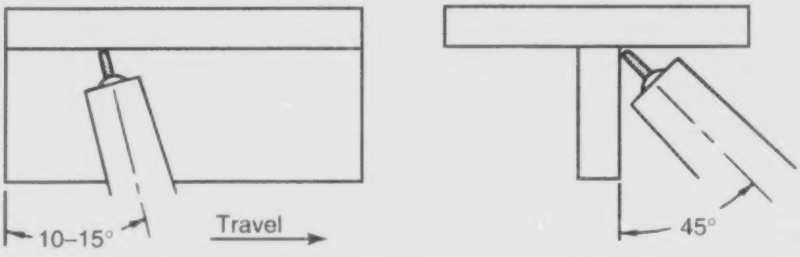
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in overhead welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 9. Use push or pull technique. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

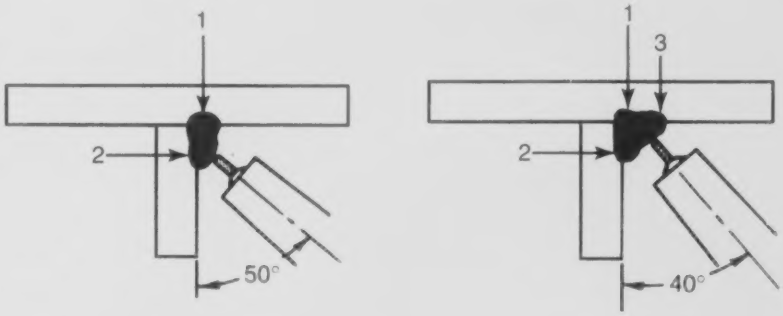
☐ 11. Clean weld with wire brush as required.

☐ 12. Inspect weld visually.

☐ 13. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 14. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated. The bead should overlap root pass by 1/2 to 2/3.

Figure 3



☐ 15. Pull the trigger and complete second bead. The weld should have equal leg dimensions.

☐ 16. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 17. Have your instructor check your work.

☐ 18. Continue with additional beads as directed by your instructor.

☐ 19. Have your instructor check your work.

☐ 20. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 21. Have your instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's Comments: ______________________

Objective 51

Job Sheet 18—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______
• Bend test	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

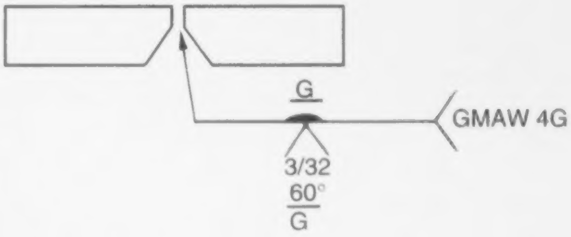
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Bend test machine
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Bend

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16" to 3/32" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for short-circuit transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

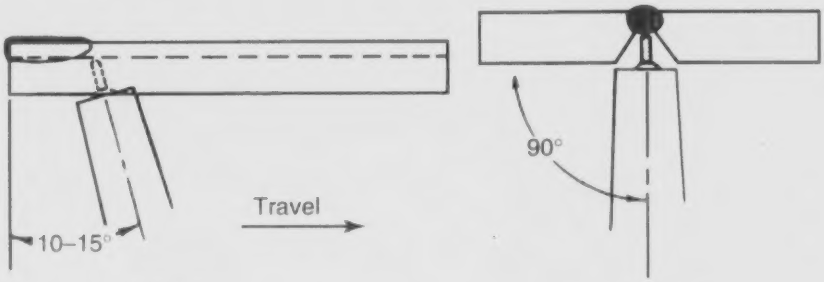
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32" opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld in overhead position.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 10. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be $^1/_{16}$″.

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as required.

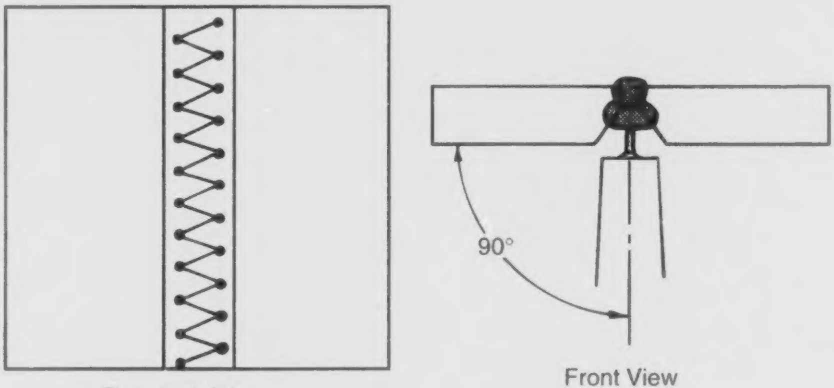
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



Pause at dots.
Bottom View

Front View

☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

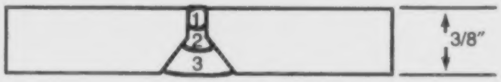
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about 1/16″ wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Prepare specimens for bend test as previously outlined.

☐ 28. Complete bend test.

☐ 29. Have your instructor check your work.

☐ 30. Shut down and secure equipment.

☐ 31. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 52

Job Sheet 19—Set Up GMAW Equipment for Spray Transfer on Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup	______
• Initial adjustments	______
• Test bead and evaluation	______
• Final adjustments	______
• Equipment shutdown	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- GMAW machine and accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Adjustable wrench
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol: N/A
2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: Flat
8. Direction of welding: Per instructor
9. Technique: Push or pull

10. Cleaning: Brush

11. Inspection: Visual

12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Attach ground clamp to the workpiece.

☐ 3. Turn the machine on.

☐ 4. Adjust voltage and amperage to approximate settings for wire size and plate thickness, and remember that these settings are higher for spray transfer than they are for short-circuit transfer.

Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

Caution: Because of the higher amperage settings, protect your eyes with darker lens shade and wear heavy duty leathers and gloves to protect your skin.

☐ 5. Place a piece of scrap metal on the work table.

☐ 6. Turn wire feed power on.

☐ 7. Place the nozzle of the gun on the piece of scrap metal so the correct electrode extension can be maintained, and remember that electrode extension should be 1/2" to 3/4" for spray transfer.

☐ 8. Press the trigger to create an arc.

☐ 9. Run a test bead. Release trigger to break the arc.

☐ 10. Make adjustments as needed to correct voltage and amperage by performing a series of test welds. Adjust parameters starting with amperage, then voltage.

☐ 11. Run a test bead on the piece of scrap metal and listen carefully for a sound that is louder and more intense than the sound heard with the short-circuit transfer, and look for a brighter arc caused by higher amperage.

☐ 12. Release the trigger and inspect the bead and make corrections as follows:

  ☐ a. If there is poor bead shape and undercutting, lower voltage and correct gun angle, electrode extension, and gas mixture.

  ☐ b. If there is excess spatter, increase inductance.

  ☐ c. If the bead is narrow and humpy, raise voltage and decrease wire feed speed.

  ☐ d. If the bead is flat and wide, lower voltage or increase wire feed speed.

☐ 13. Repeat procedure until settings are proper and bead has good appearance.

☐ 14. Release trigger, put gun in safe place, and inspect your bead for good penetration, good fusion, and uniform bead width with minimum spatter.

☐ 15. Have your instructor check your work.

☐ 16. Set wire speed feed to zero if no gas purge switch is available.

☐ 17. Turn off gas supply.

☐ 18. Depress gun trigger to relieve shielding gas pressure, or depress gas purge switch.

☐ 19. Allow ball in flow meter to return to zero. Close the flow meter finger tight.

☐ 20. Turn off feed control power switch, if applicable.

☐ 21. Turn off welding machine power supply.

☐ 22. Store gun, cable assembly, and ground clamp in a safe place.

☐ 23. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 53

Job Sheet 20—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

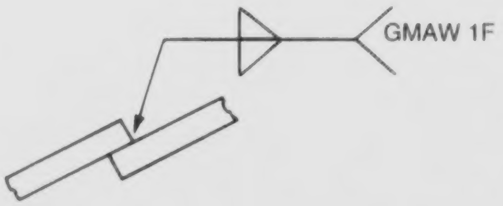
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

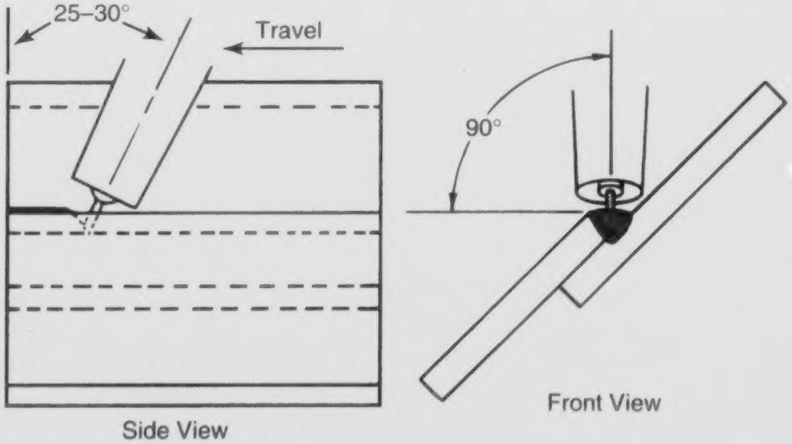
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates at 45° angle.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint. Move straight and quickly along the joint. You should not have to weave much. Stay on leading edge of puddle.

☐ 9. Crater and fill to end the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with wire brush as required.

Note: You may have to cool the joint in water.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 54

Job Sheet 21—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

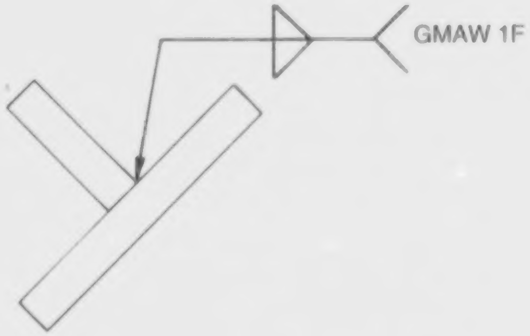
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Mild steel as selected by instructor
- Wire-cutting pliers and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

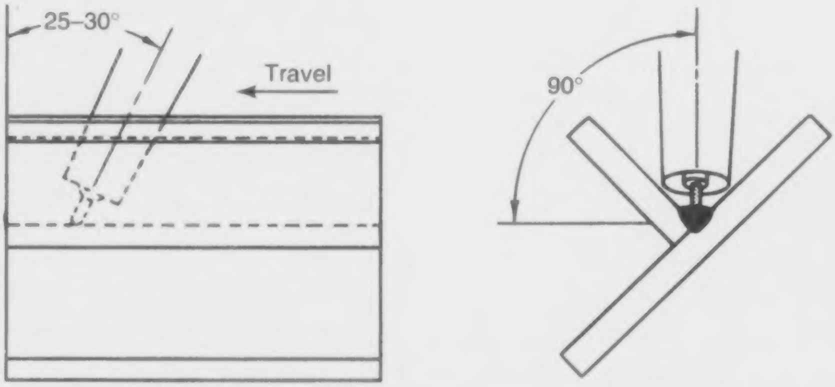
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates at a 45° angle.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and form a puddle on one of the tack points so that it fuses with both edges of the joint. Move straight and quickly along the joint. You should not have to weave much. Stay on leading edge of puddle. The weld bead should have equal leg dimensions, and the bead face should be flat to slightly convex.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean the joint with wire brush as required.

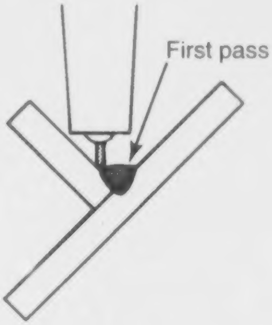
Note: You may have to cool the joint occasionally in water.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim as required, but do not arc excess wire off on the side of the work table. The weld bead should overlap root pass by 1/2 to 2/3.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.

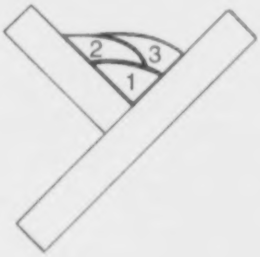
Figure 3



☐ 14. Pull the trigger and complete second bead.

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal. The weld bead should have equal leg dimensions and should overlap by 1/2 to 2/3.

Figure 4



☐ 16. Have your instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat procedure for the other side of the joint, if required by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 55

Job Sheet 22—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position

Name ________________________ Attempt Number ______

Date ________________________ Overall Rating ______

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

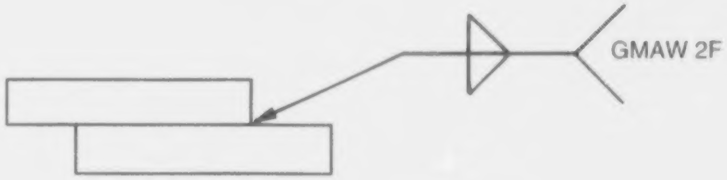
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

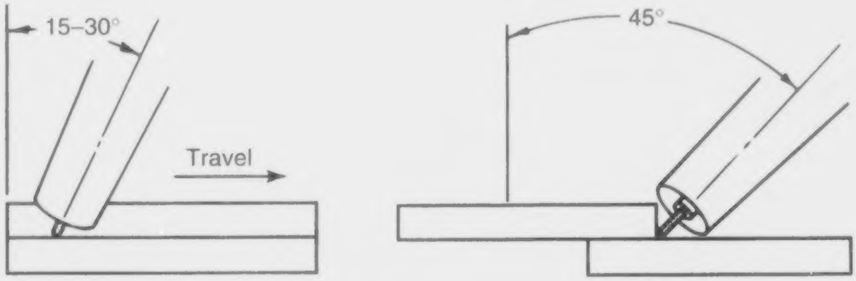
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and form a puddle on one of the tack points so that it fuses with both edges of the joint. Move straight and quickly along the joint. You should not have to weave much. Stay on leading edge of puddle.

☐ 9. Crater and fill to end the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with wire brush as required.

Note: You may have to cool the joint occasionally in water.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 56

Job Sheet 23—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

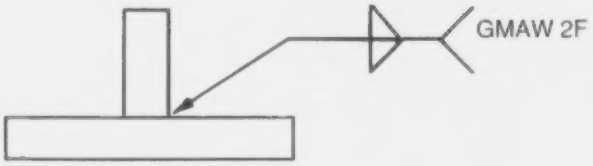
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor

6. Electrical: DCEP

7. Position: 2F

8. Technique: Push or pull

9. Cleaning: Brush

10. Inspection: Visual

11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

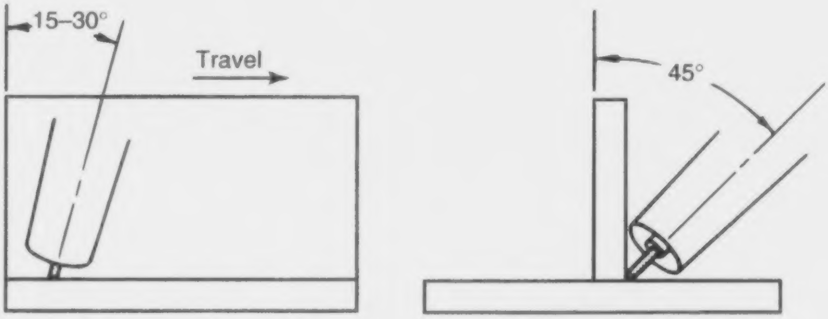
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and form a puddle on one of the tack points so that it fuses with both edges of the joint. Move straight and quickly along the joint. You should not have to weave much. Stay on leading edge of puddle. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

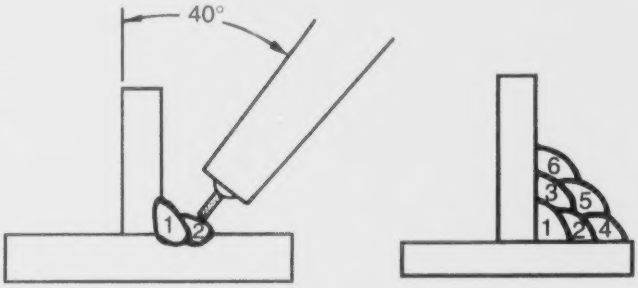
Note: You may have to cool the joint occasionally in water.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table. The weld bead should overlap root pass by 1/2 to 2/3.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.

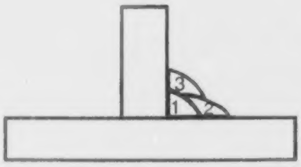
Figure 3



☐ 14. Pull the trigger and complete second bead.

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal. The weld bead should overlap by 1/2 to 2/3. The weld should have equal leg dimensions.

Figure 4



☐ 16. Have instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have instructor check your work.

☐ 19. Repeat the procedure for the other side of the joint, if directed by your instructor.

☐ 20. Have instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's Comments: ____

____

____

Objective 57

Job Sheet 24—Use Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding and crater and fill technique, first pass	______
• Welding and crater and fill technique, second pass	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

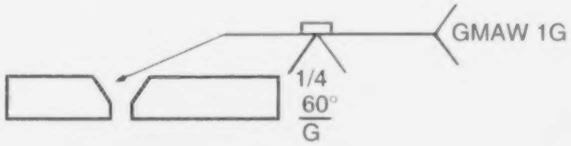
Tools, equipment, and materials

- GMAW machine with accessories
- Wire and shielding gas to specifications
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor

6. Electrical: DCEP

7. Position: 1G

8. Technique: Push or pull

9. Cleaning: Brush

10. Inspection: Visual

11. Testing: N/A

Procedure

☐ 1. Prepare plates with 30° bevels. There will not be a root face.

☐ 2. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 3. Complete setup for spray transfer as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Position plates on top of 1/4″ backing strip. Support plates with additional 1/4″ plates.

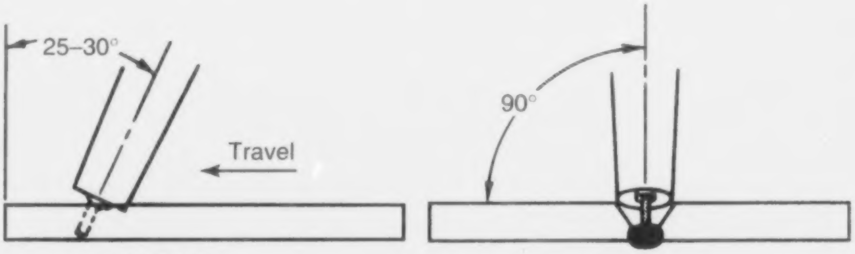
☐ 7. Make a 1/4″ root opening and tack weld each end.

☐ 8. Tack back side of plate.

☐ 9. Turn plates over and position for joint weld as specified.

☐ 10. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

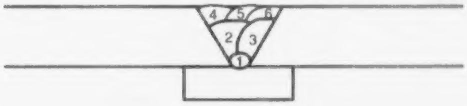
☐ 11. Deposit first weld bead by moving quickly and evenly. Do not weave. Bead should be flat.

☐ 12. Deposit second weld bead using the push method. Overlap the root pass by $^{2}/_{3}$. Bead should be flat.

☐ 13. Deposit third weld. Overlap the second by $^{2}/_{3}$. Bead should be flat.

☐ 14. Deposit your cap passes. Use a two or three bead cap pass, whichever you prefer. Weld should be flat to a slightly convex finish.

Figure 3



☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 58

Job Sheet 25—Set Up GMAW Equipment for Spray Transfer on Aluminum

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Test bead inspection	______
• Equipment shut down	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol: N/A
2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push

9. Cleaning: Stainless steel brush

10. Inspection: Visual

11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Attach ground clamp to the workpiece.

☐ 3. Turn the machine on.

☐ 4. Adjust voltage and amperage to approximate settings for wire size and plate thickness, and remember that these settings are higher for spray transfer than they are for short-circuit transfer.

Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

Caution: Because of the higher amperage settings, protect your eyes with darker lens shade and wear heavy duty leathers and gloves to protect your skin.

☐ 5. Place a piece of scrap aluminum on the work table.

☐ 6. Turn wire feed power on.

☐ 7. Place the nozzle of the gun on the piece of aluminum so that the correct electrode extension can be maintained. Remember that electrode extension should be 1/2″ to 3/4″ for spray transfer.

☐ 8. Press the trigger to create an arc and run test bead. Release trigger to break arc.

☐ 9. Make adjustments as needed to correct voltage and amperage by performing a series of test welds. Adjust parameters starting with amperage, then voltage.

☐ 10. Run a test bead on the piece of scrap aluminum and listen carefully for a sound that is louder and more intense than the sound heard with the short-circuit transfer, and look for a brighter arc caused by higher amperage.

☐ 11. Release the trigger and inspect the bead and make corrections as follows:

  ☐ a. If there is poor bead shape and undercutting, lower voltage and correct gun angle, electrode extension, and gas mixture.

  ☐ b. If there is excess spatter, increase inductance.

  ☐ c. If the bead is narrow and humpy, raise voltage and decrease wire feed speed.

  ☐ d. If the bead is flat and wide, lower voltage or increase wire feed speed.

☐ 12. Repeat procedure until settings are proper and bead has good appearance.

☐ 13. Release trigger, put gun in safe place, and inspect your bead for good penetration, good fusion, and uniform bead width with minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Set wire speed feed to zero if no gas purge switch is available.

☐ 16. Turn off gas supply.

☐ 17. Depress gun trigger to relieve shielding gas pressure, or depress gas purge switch.

☐ 18. Allow ball in flow meter to return to zero. Close the flow meter finger tight.

☐ 19. Turn off feed control power switch, if applicable.

☐ 20. Turn off welding machine power supply.

☐ 21. Store gun, cable assembly, and ground clamp in a safe place.

☐ 22. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 59

Job Sheet 26—Prepare Aluminum for GMAW

Name ______________________ Attempt Number ________

Date ______ ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Use of portable grinder	____
• Edge preparation	____
• Oxide removal	____

Basic Skills

Reading

Critical Thinking

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Aluminum as selected by instructor
- Portable grinder with nonferrous grinding discs
- Stainless steel brush and clean shop rags
- Metal cleaner/deoxidizer solution
- Personal safety clothing and safety glasses
- Pliers and clamps

Procedure

☐ 1. Secure the workpiece with pliers and clamps.

☐ 2. Use the portable sander to remove oxide, dirt, and paint from all surfaces.

☐ 3. Grind or file edges of joints for specified edge preparation, and be sure to use nonferrous grinding discs.

☐ 4. Wet a shop rag with metal cleaner/deoxidizer, and wipe the plate to remove any oxide residue.

☐ 5. Wipe the plate dry with a clean shop rag.

☐ 6. Have your instructor check your work.

☐ 7. Store prepared workpiece in a dry place, and weld as soon after cleaning as possible.

Evaluator's Comments: ______________________________

Objective 60

Job Sheet 27—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

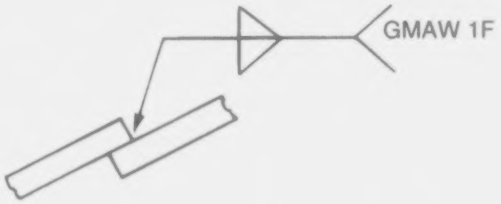
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  — 100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  — 65% Helium/35% Argon (Higher heat input)
  — 75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer on aluminum as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

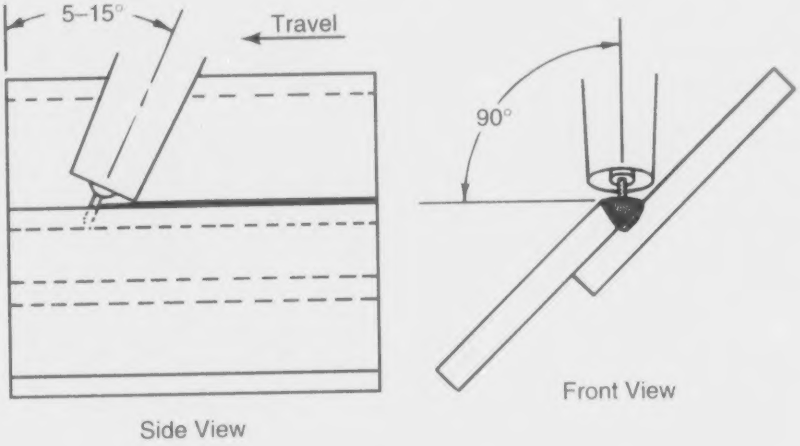
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates at a 45° angle.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

Objective 61

Job Sheet 28—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

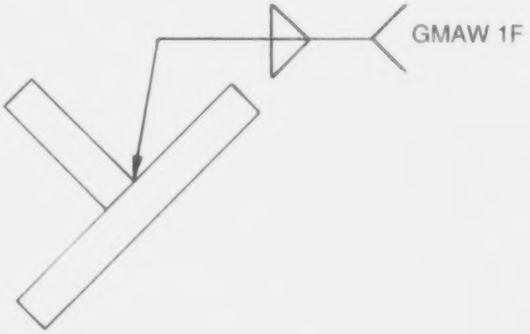
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Aluminum as selected by instructor
- Wire-cutting pliers and stainless steel wire brush
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

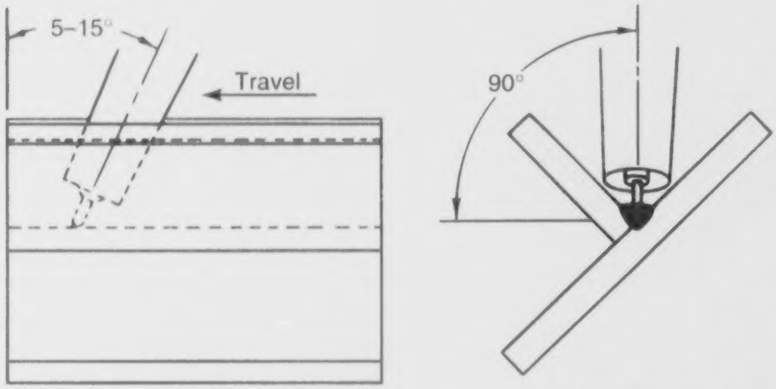
☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates at a 45° angle.

349

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean the joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Repeat procedure for the other side of the joint if required by your instructor.

☐ 15. Have your instructor check your work.

☐ 16. Shut down and secure equipment.

☐ 17. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 62

Job Sheet 29—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

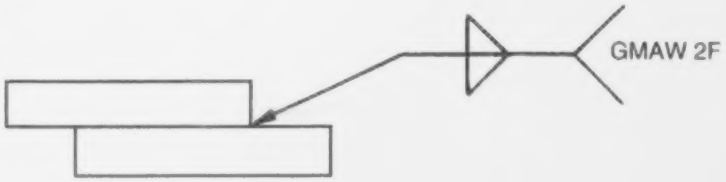
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

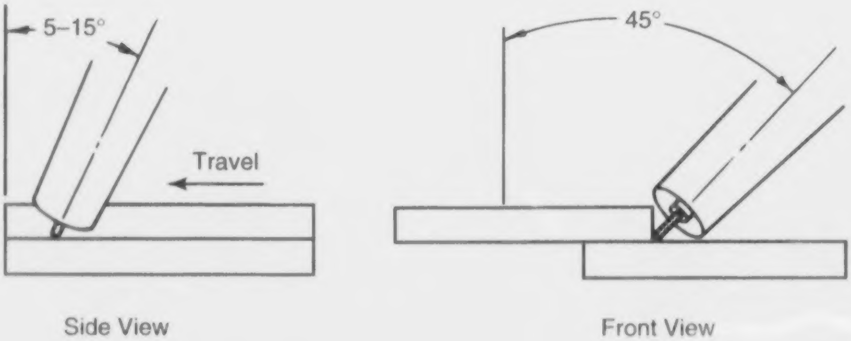
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Side View Front View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 63

Job Sheet 30—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

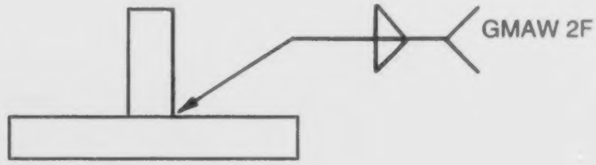
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

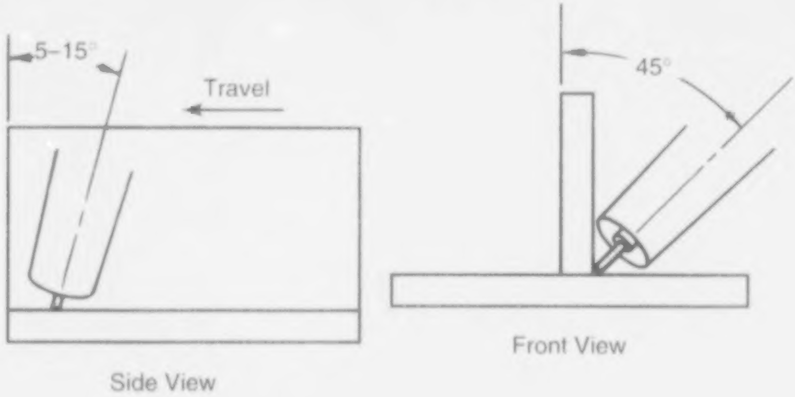
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



355

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 64

Job Sheet 31—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Up Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

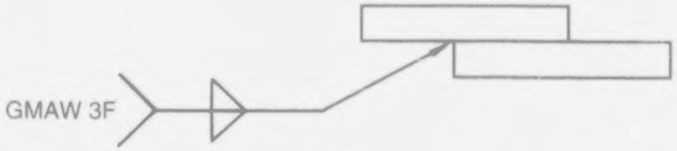
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



Top View

2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical up
9. Technique: Push
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

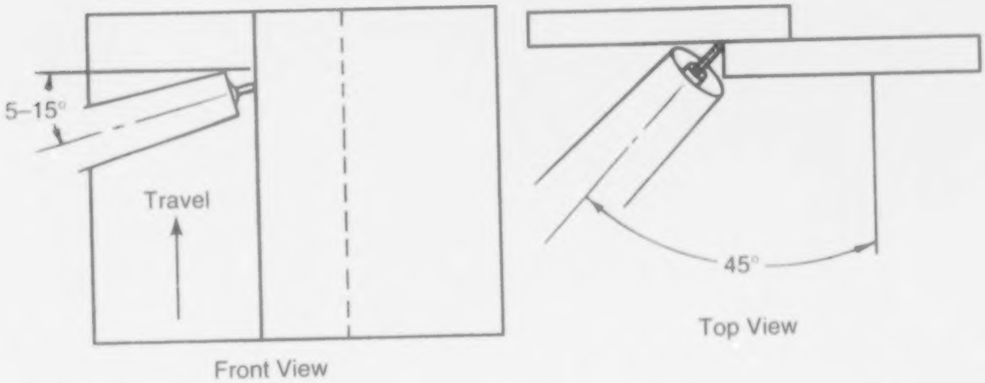
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in vertical up welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 65

Job Sheet 32—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

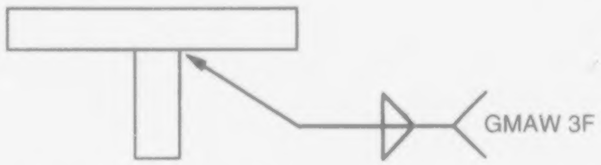
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



Top View

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical up
9. Technique: Push
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

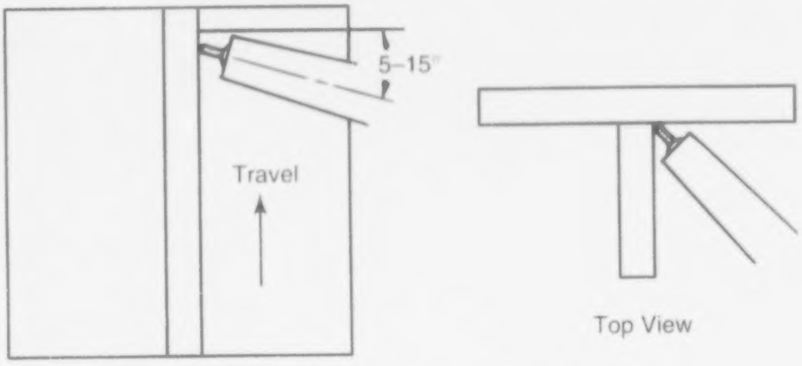
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in vertical up welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Front View

Top View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 66

Job Sheet 33—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

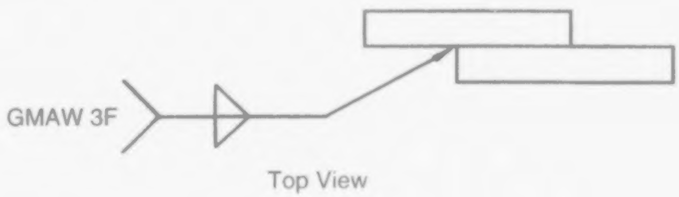
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical down
9. Technique: Pull
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

Note: Voltage for vertical down will need to be increased slightly more than for vertical up, and travel speed for vertical down is faster than for vertical up.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

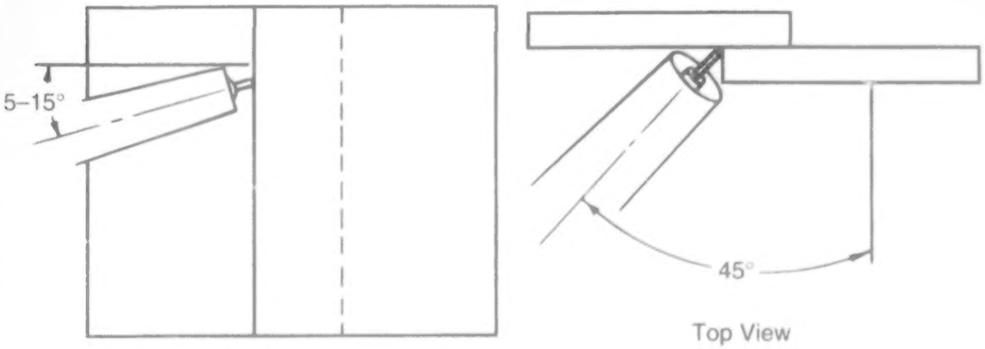
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in vertical down welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Front View

Top View

☐ 8. Squeeze gun trigger and use a pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions with flat face contour.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 67

Job Sheet 34—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

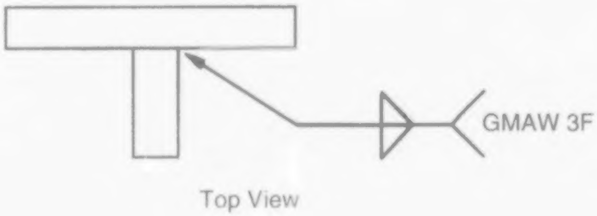
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical down
9. Technique: Pull
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

Note: Voltage for vertical down will need to be increased slightly more than for vertical up, and travel speed for vertical down is faster than for vertical up.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

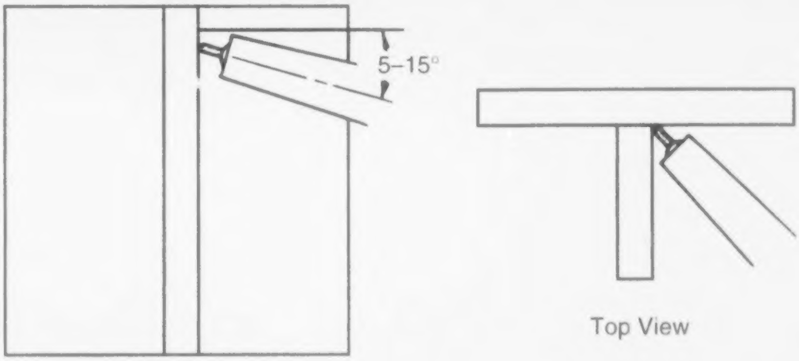
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in vertical down welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



Front View

Top View

☐ 8. Squeeze gun trigger and use a pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions with flat face contour.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 68

Job Sheet 35—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

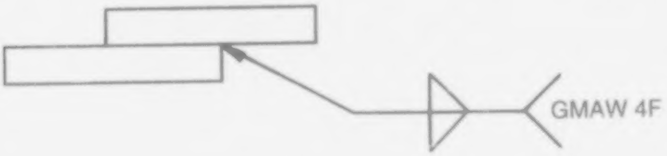
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

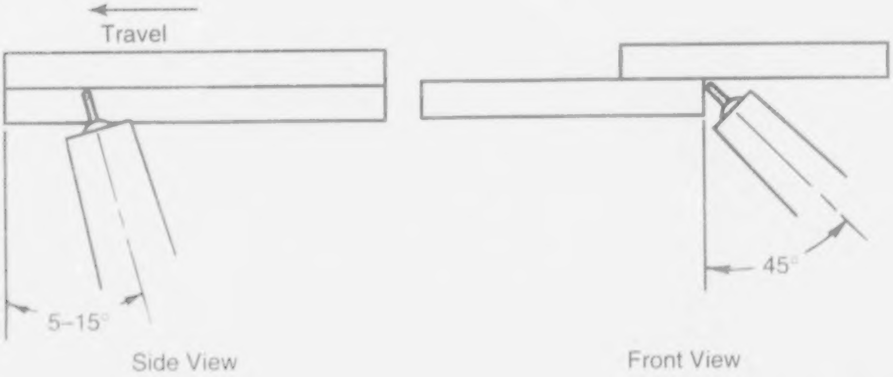
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in overhead welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 69

Job Sheet 36—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

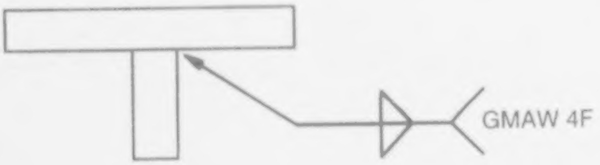
Tools, equipment, and materials

- GMAW machine with accessories
- Wire to specifications
- Shielding gas to specifications
  - —100% Argon (Best metal transfer, least spatter, and best choice on 0 to 1 inch thick aluminum)
  - —65% Helium/35% Argon (Higher heat input)
  - —75% Helium/25% Argon (Minimizes porosity, faster travel speeds on sheet metal)
- Wire-cutting pliers and stainless steel wire brush
- Aluminum as selected by instructor
- Personal safety clothing, equipment, and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor

3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

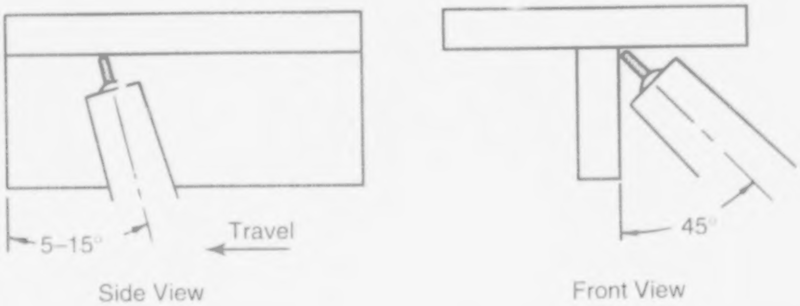
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in overhead welding position.

☐ 7. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. The weld bead should have equal leg dimensions and bead face should be flat to slightly convex

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

Objective 70

Job Sheet 37—Set Up GMAW-P Equipment for Pulsed-Spray Transfer on Mild Steel

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Flow meter and regulator setup	______
• Amp/lpm adjustment and selected voltage	______
• Proper electrode extension	______
• Test bead evaluation	______
• Proper shut down procedure	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- GMAW-P machine and accessories
- Selected shielding gas (Must meet at least 80% minimum argon content.)
- Selected wire
- Personal safety clothing and safety glasses
- Adjustable wrench
- Selected mild steel (oxide-free plate)

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas and adjust the flow rate as previously outlined.

☐ 2. Attach ground clamp to the workpiece.

☐ 3. Turn the machine on.

☐ 4. Turn the wire feed power on, if applicable.

☐ 5. Preset voltage and wire feed speed to approximate settings for wire size and plate thickness.

☐ 6. Conduct test welds to fine tune machine.

☐ 7. Make adjustments as needed to correct voltage and amperage.

☐ 8. Run a test bead on the piece of scrap metal, and inspect bead for proper shape and size.

☐ 9. Lower voltage or increase wire feed speed if the bead is flat and wide.

☐ 10. Raise voltage if the bead is narrow and humpy.

☐ 11. Increase inductance (arc control), if there is excess spatter.

☐ 12. Correct the gun angle, electrode extension, or travel speed if the bead has poor shape or undercutting.

☐ 13. Run another test bead to achieve proper setting and get a good bead appearance.

☐ 14. Inspect your test bead for good penetration, good fusion, and uniform width with minimum spatter.

☐ 15. Have your instructor check your work.

☐ 16. Set wire speed feed and voltage to zero.

☐ 17. Turn off gas supply.

☐ 18. Depress gas purge to relieve shielding gas pressure.

☐ 19. Allow ball in flow meter to return to zero.

☐ 20. Turn off feed control power switch, if applicable.

☐ 21. Turn off welding machine power supply.

☐ 22. Store gun, cable assembly, and ground clamp in proper storage.

☐ 23. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 71

Job Sheet 38—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding and crater and fill technique, first pass	______
• Welding and crater and fill technique, second pass	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

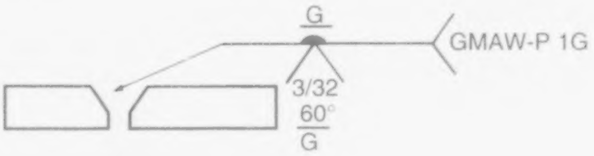
Tools, equipment, and materials

- GMAW-P machine with accessories
- Wire and shielding gas with minimum 80% argon content
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor

6. Electrical: DCEP
7. Position: 1G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16" to 3/32" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for pulsed-spray transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

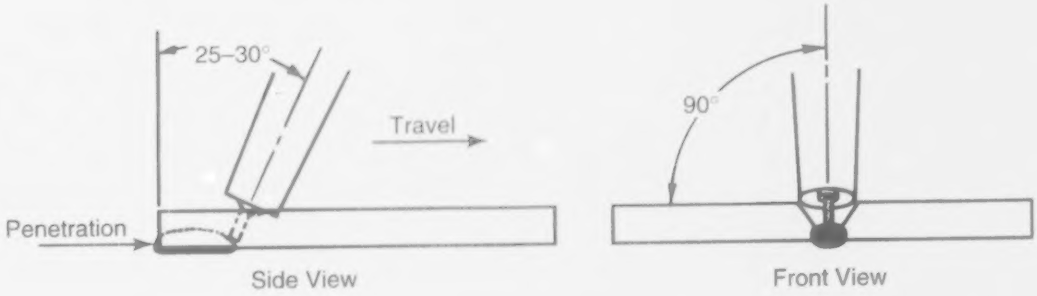
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32" opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



378

☐ 10. Squeeze gun trigger and use push or pull technique. Form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be 1/16".

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as required.

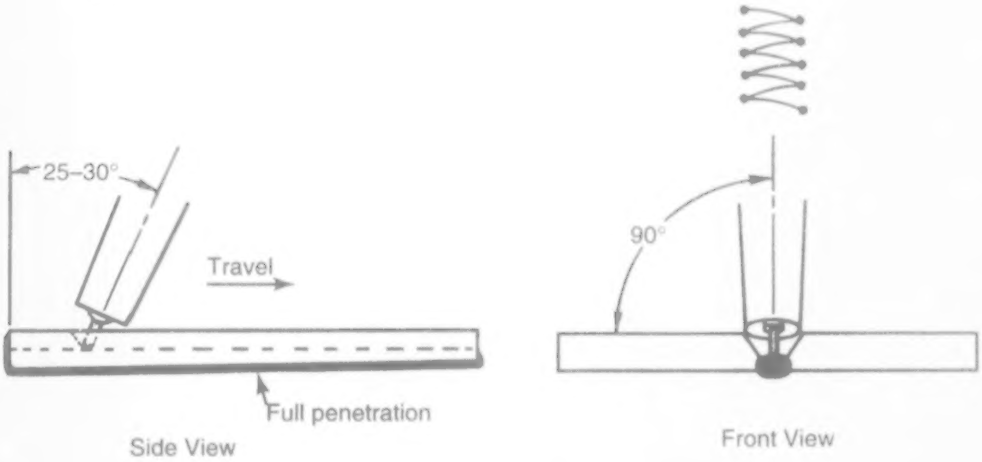
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

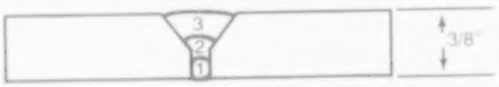
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about $^1/_{16}$" wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 72

Job Sheet 39—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

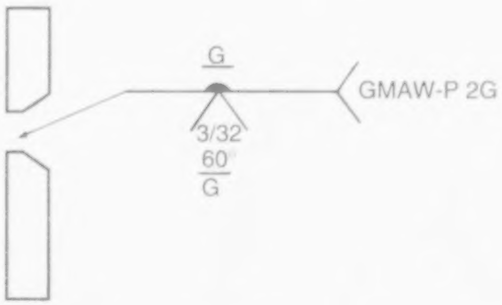
Tools, equipment, and materials

- GMAW-P machine with accessories
- Wire and shielding gas with minimum 80% argon content
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a $^{1}/_{16}$" to $^{3}/_{32}$" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for pulsed-spray transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

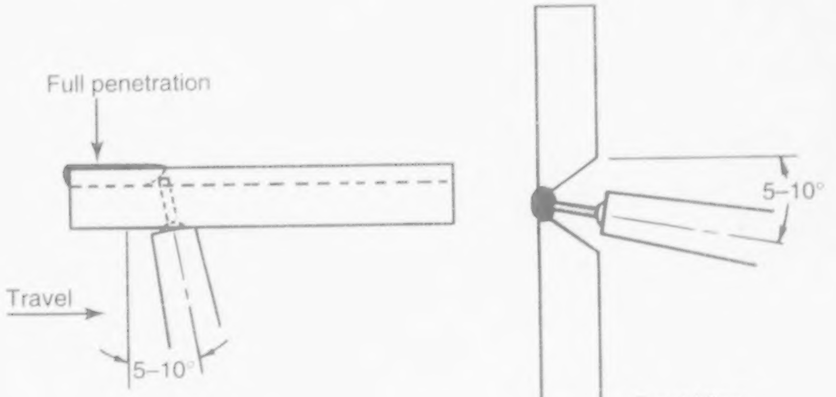
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a $^{3}/_{32}$" root opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



Top View

Front View

☐ 10. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. Stay on leading edge of puddle. Root reinforcement should be 1/16″.

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as specified.

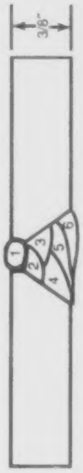
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Overlap root pass by about 1/2 to 2/3.

Figure 3



☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Deposit third weld bead. Use weave or oval motion. Overlap second pass by about 1/3 to 1/2. Make sure you tie into top bevel.

☐ 19. Check electrode extension for start of cap bead, and trim wire as required.

☐ 20. Deposit fourth weld bead. Lower toe should penetrate 1/16″ into surface of base metal to ensure complete fusion.

☐ 21. Deposit fifth weld bead. Overlap fourth pass by about 1/2 to 2/3.

☐ 22. Deposit sixth weld bead. Overlap fifth pass by about 1/2 to 2/3. Top toe should overlap top edge of joint by about 1/8" to ensure complete fusion.

☐ 23. Clean and inspect cap pass, and put gun in safe place.

☐ 24. Have your instructor check your work.

☐ 25. Shut down and secure equipment.

☐ 26. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 73

Job Sheet 40—Use Pulsed-Spray Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

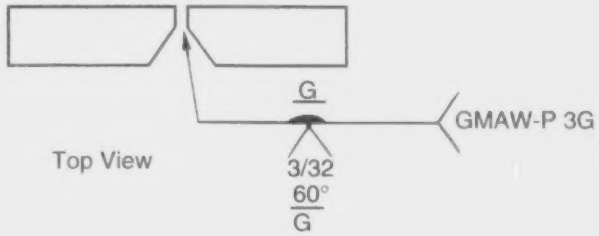
Tools, equipment, and materials

- GMAW-P machine with accessories
- Wire and shielding gas with minimum 80% argon content
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3G
8. Direction of welding: Vertical
9. Technique: Weave
10. Cleaning: Brush
11. Inspection: Visual

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16″ to 3/32″ root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for pulsed-spray transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

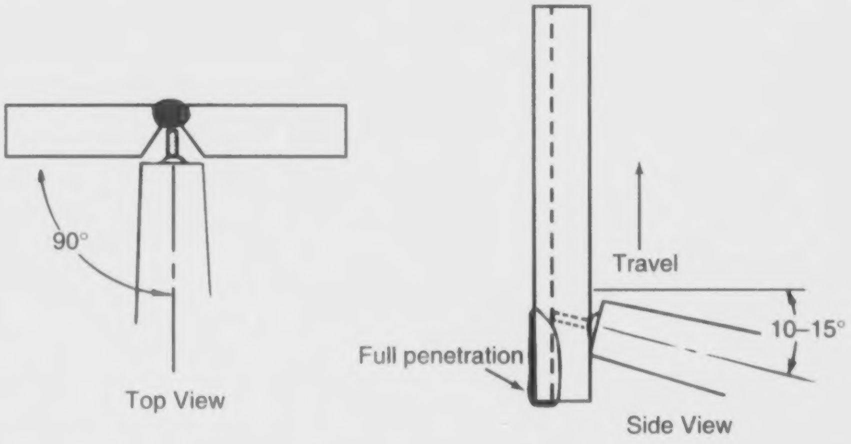
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32″ opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



Top View

Side View

☐ 10. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be 1/16".

☐ 11. Crater and fill to end the weld, and put gun in safe place.

☐ 12. Clean joint with wire brush as required.

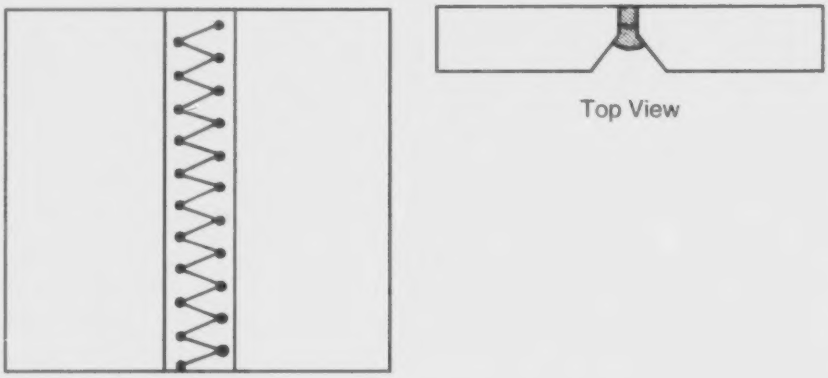
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



Pause at dots.

Top View

☐ 17. Crater and fill to end the weld, and put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

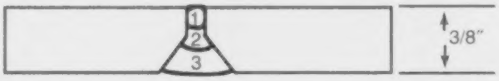
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about 1/16" wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



Top View

☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

Objective 74

Job Sheet 41—Set Up STT Equipment for Surface Tension Transfer on Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Flow meter and regulator setup	______
• Peak, background, and tailout adjustment	______
• Proper electrode extension	______
• Test bead evaluation	______
• Proper shut down procedure	______

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- STT machine and accessories
- Selected shielding gas (CO_2 or C-25)
- Selected wire
- Personal safety clothing and safety glasses
- Adjustable wrench
- Selected mild steel

Note: Refer to Student Supplement 4 for initial STT settings before beginning this job sheet.

Procedure

☐ 1. Attach the flow meter regulator to the shielding gas and adjust the flow rate as previously outlined.

☐ 2. Attach ground clamp to the workpiece and attach arc sensing lead.

☐ 3. Turn the machine on.

☐ 4. Turn the wire feed power on, if applicable.

☐ 5. Adjust peak current and background current and wire feed speed to approximate settings for wire size and plate thickness.

Note: Wire speed feed does not control current on STT.

☐ 6. Place a piece of scrap metal on the work table.

☐ 7. Run a test bead on the piece of scrap metal.

☐ 8. Release the trigger and inspect the bead.

☐ 9. Adjust peak current and background current for desired bead appearance.

☐ 10. Increase tailout, if there is excess spatter.

☐ 11. Correct the gun angle, electrode extension, or travel speed if the bead has poor shape or undercutting.

☐ 12. Run another test bead to achieve proper setting and get a good bead appearance.

☐ 13. Inspect your test bead for good penetration, good fusion, and uniform width with minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Set wire speed feed and current to zero.

☐ 16. Turn off gas supply.

☐ 17. Depress gas purge to relieve shielding gas pressure.

☐ 18. Allow ball in flow meter to return to zero.

☐ 19. Turn off feed control power switch, if applicable.

☐ 20. Turn off welding machine power supply.

☐ 21. Store gun, cable assembly, and ground clamp in proper storage.

☐ 22. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 75

Job Sheet 42—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______ ____________________ Attempt Number ______

Date ____________________ Overall Rating ______

Evaluation Criteria	Rating
• Equipment setup	______
• Set adjustments	
Peak—Controls arc length	______
Background—Controls bead shape	______
Tailout—Smoothes bead	______
Eliminates premature shorts	______
• Electrode extension	______
• Welding technique	
(Can be filled and capped with faster processes, if desired)	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

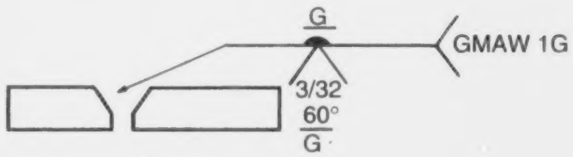
Tools, equipment, and materials

- STT machine and wire feeder with accessories
- Wire and shielding gas (CO_2 or C-25)
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: .045

4. Peak, background, and tailout: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16" to 3/32" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for surface tension transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

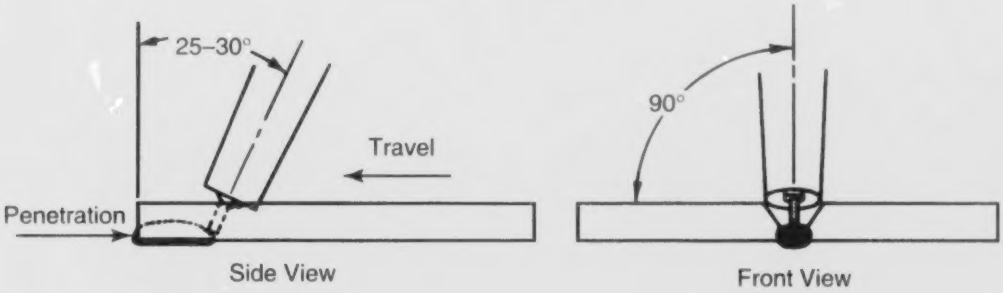
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32" opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension. Use push or pull technique.

Figure 2



☐ 10. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be 1/16".

☐ 11. Put gun in safe place.

☐ 12. Clean joint with wire brush as specified.

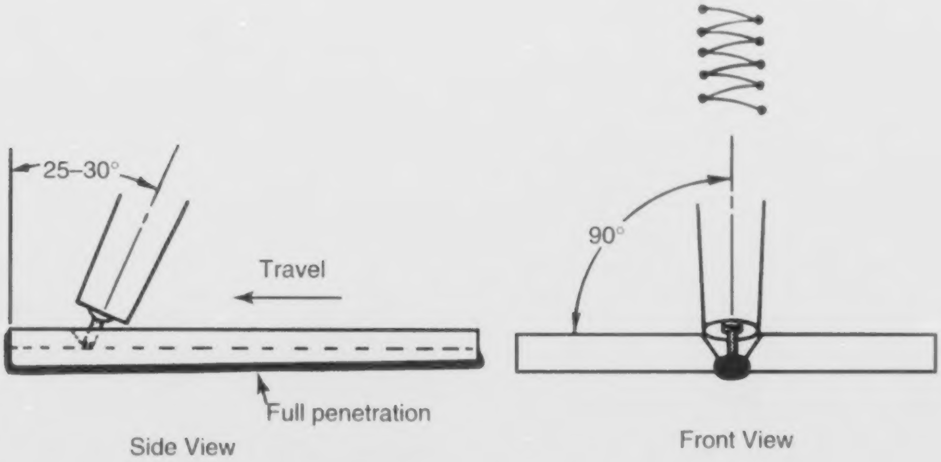
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



☐ 17. Put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

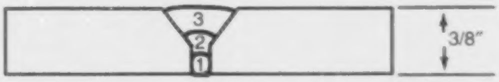
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about 1/16" wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

Objective 76

Job Sheet 43—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position

Name ______ ____________________ Attempt Number ______

Date ____________________ Overall Rating ______

Evaluation Criteria	Rating
• Equipment setup	______
• Set adjustments	
Peak—Controls arc length	______
Background—Controls bead shape	______
Tailout—Smoothes bead	______
Eliminates premature shorts	______
• Electrode extension	______
• Welding technique (Can be filled and capped with faster processes, if desired)	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

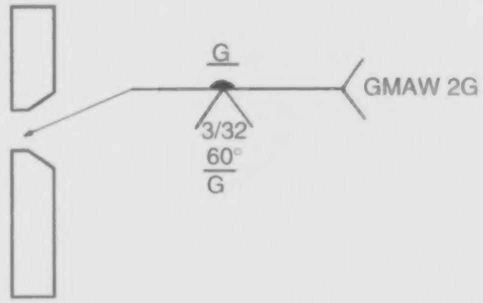
Tools, equipment, and materials

- STT machine and wire feeder with accessories
- Wire and shielding gas (CO_2 or C-25)
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: .045
4. Peak, background, and tailout: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16" to 3/32" root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for surface tension transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

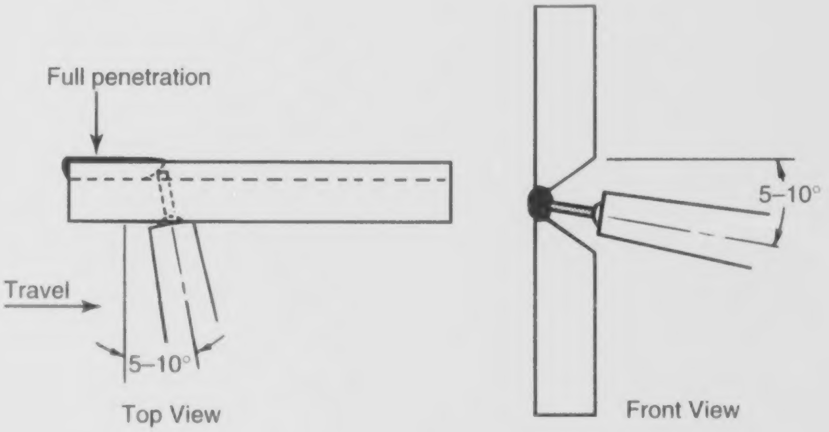
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32" opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 10. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension. Stay on leading edge of puddle. Root reinforcement should be 1/16″.

☐ 11. Put gun in safe place.

☐ 12. Clean joint with wire brush as required.

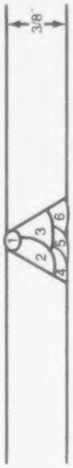
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Overlap root pass by about 1/2 to 2/3.

Figure 3



☐ 17. Put gun in safe place.

☐ 18. Deposit third weld bead. Use weave or oval motion. Overlap second pass by about 1/3 to 1/2. Make sure you tie into top bevel.

☐ 19. Check electrode extension for start of cap bead, and trim wire as required.

☐ 20. Deposit fourth weld bead. Lower toe should penetrate 1/16" into surface of base metal to ensure complete fusion.

☐ 21. Deposit fifth weld bead. Overlap fourth pass by about 1/2 to 2/3.

☐ 22. Deposit sixth weld bead. Overlap fifth pass by about 1/2 to 2/3. Top toe should overlap top edge of joint by about 1/8" to ensure complete fusion.

☐ 23. Clean and inspect cap pass, and put gun in safe place.

☐ 24. Have your instructor check your work.

☐ 25. Shut down and secure equipment.

☐ 26. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 77

Job Sheet 44—Use Surface Tension Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Equipment setup	______
• Set adjustments	
Peak—Controls arc length	______
Background—Controls bead shape	______
Tailout—Smoothes bead	______
Eliminates premature shorts	______
• Electrode extension	______
• Welding technique (Can be filled and capped with faster processes, if desired)	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

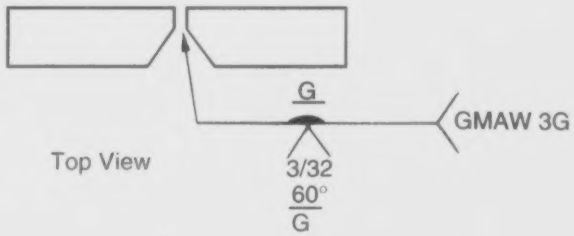
Tools, equipment, and materials

- STT machine and wire feeder with accessories
- Wire and shielding gas (CO_2 or C-25)
- Wire-cutting pliers and wire brush
- Mild steel as selected by instructor
- Personal safety clothing and equipment

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire: Per instructor
3. Wire size: .045
4. Peak, background, and tailout: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3G
8. Direction of welding: Vertical
9. Technique: Weave
10. Cleaning: Brush
11. Inspection: Visual

Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16″ to 3/32″ root face.

☐ 2. Remove burrs on back side of plates.

☐ 3. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 4. Complete setup for surface tension transfer as previously outlined.

☐ 5. Adjust controls for plate thickness and wire diameter.

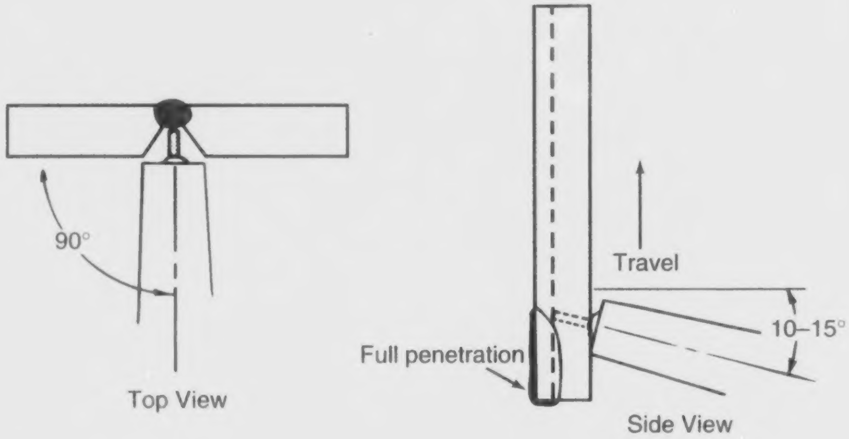
☐ 6. Make a test bead on scrap metal and make required adjustments.

☐ 7. Position plates upside down on work table and tack both ends of joint, leaving a 3/32″ opening, although opening will vary with metal thickness.

☐ 8. Turn plates over and position for joint weld as specified.

☐ 9. Position gun at correct angle to joint and check electrode extension.

Figure 2



☐ 10. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint. Stay on leading edge of puddle. Root reinforcement should be 1/16″.

☐ 11. Put gun in safe place.

☐ 12. Clean joint with wire brush as required.

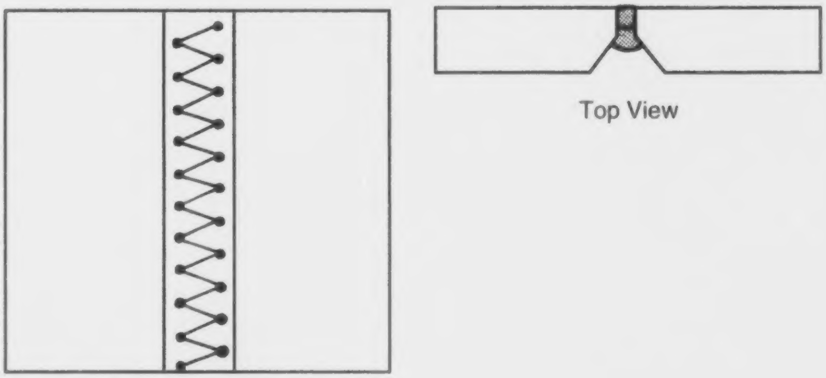
☐ 13. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 14. Have your instructor check your work.

☐ 15. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 16. Reposition gun and use a weaving technique to lay a second pass over the first bead. Pause briefly at each toe to ensure complete fusion. Stay on leading edge of puddle.

Figure 3



Pause at dots.

Top View

☐ 17. Put gun in safe place.

☐ 18. Clean and inspect second bead.

☐ 19. Have your instructor check your work.

☐ 20. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal or just below flush.

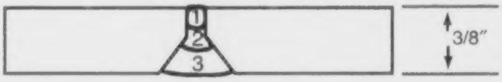
☐ 21. Clean and inspect the final fill bead.

☐ 22. Have your instructor check your work.

☐ 23. Check electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving technique to place the cap pass on the joint making the weld about 1/16″ wider than the joint to ensure complete penetration. Stay on leading edge of puddle.

Figure 4



Top View

☐ 25. Clean and inspect cap pass.

☐ 26. Continue to practice as directed by your instructor.

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 18

Job Sheet 1—Set Up or Replace Wire on a Flux-Cored Wire Feeder

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment safety	______
• Proper removal of old spool	______
• New spool set up to feed from bottom or top	______
• Wire properly fed through roller	______
• Wire-inch control properly used	______
• Pinch test used to test wire tension	______
• Wire properly prepared for welding activity	______

Basic Skills

Reading

Critical Thinking

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Screwdriver, adjustable wrench, and pliers
- Wire-cutting pliers and fine-cut file
- Personal safety clothing and safety glasses

Procedure

☐ 1. Shut off input power to the power supply and wire feeder.

☐ 2. Get a firm hold on the wire near the pressure rollers, if you are replacing a partial spool.

☐ 3. Cut the wire with wire-cutting pliers near the pressure rollers, or relieve pressure rollers and manually rewind spool of wire unless cold wire feed reverse capability is available.

☐ 4. Locate the small-diameter hole on the outside edge of the spool, put the end of the cut wire into it, and tie the loose end.

☐ 5. Remove the nozzle from the FCAW gun.

☐ 6. Press the gun trigger switch and run the cut wire past the pressure rollers, and then release the gun trigger switch.

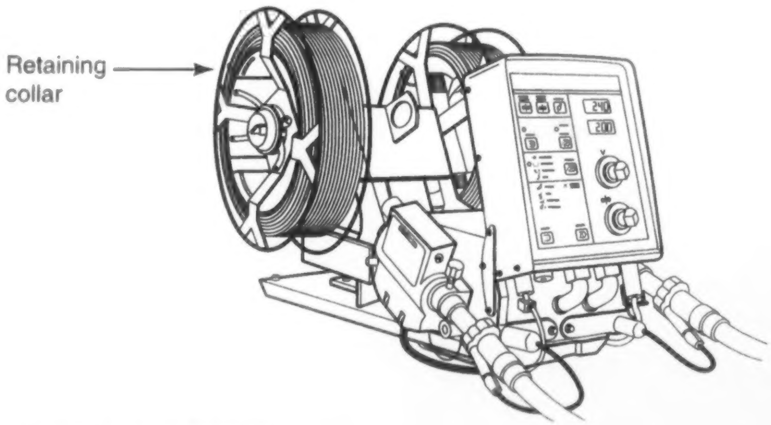
☐ 7. Pull the remaining wire through the cable and dispose of it, if you are replacing a partial or empty spool.

☐ 8. Remove the contact tip.

☐ 9. Remove the retaining collar that holds the spool in place.

Note: Different manufacturers of FCAW equipment use various methods of spool attachment.

Figure 1



Courtesy of Lincoln Electric Company.

☐ 10. Remove the empty or partially used spool from the spindle and store in proper location.

Note: The following procedures are for initial setup or for wire replacement.

☐ 11. Locate the end of the wire on the new spool and position the new spool so that wire will feed from the bottom (or top of wire feeder if so situated) of the spool into the wire feeder.

> **Caution:** Do not remove the free end of the wire from the retaining hold where it is secure or you will have wire all over the place.

☐ 12. Place the new spool of wire onto the spindle and make sure the drag brake pin slips into the proper hole.

☐ 13. Place the retaining collar back on the spindle and force it tightly against the reel.

☐ 14. Locate the end of the wire on the spool, free it from the retaining hold, and clip the end of the wire.

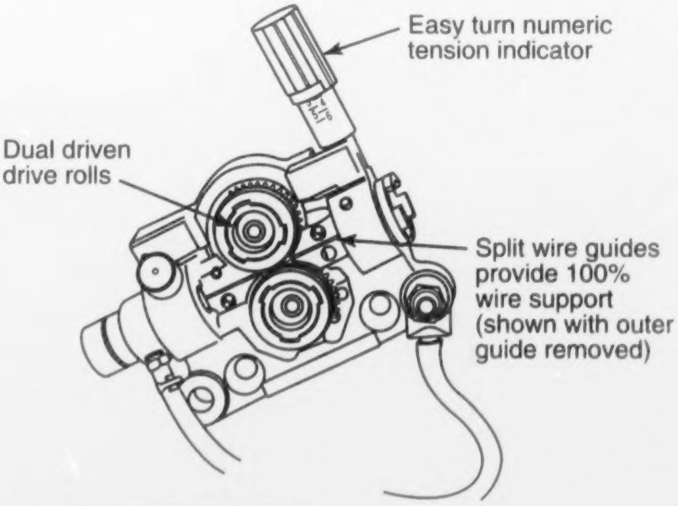
> **Caution:** Hang on to the free end of the wire firmly throughout this procedure.

☐ 15. Use a file to smooth the sharp end of the wire, or clip the wire at an angle for easy feeding.

☐ 16. Release pressure on the top drive rollers by loosening tension indicator, then raise the top roller.

☐ 17. Guide the wire through the split wire guide system and use both hands to push and pull the wire across the bottom drive roll and through the other side of the split wire guide system.

Figure 2


Easy turn numeric tension indicator
Dual driven drive rolls
Split wire guides provide 100% wire support (shown with outer guide removed)

Courtesy of Lincoln Electric Company.

☐ 18. Continue pushing and pulling the wire until it moves into and through the wire feed power assembly 2″ to 3″.

> **Caution:** Do not force the wire into the wire feed assembly, just work it back and forth until it fits smoothly.

☐ 19. Bring top feed roll down so that the wire lies in the groove between both the rollers.

☐ 20. Use the pressure adjusting screw to provide operating pressure between the bottom and top rollers.

> **Caution:** Do not overtighten the adjusting screw and cause the wire to flatten out.

☐ 21. Turn power supply on and wire feed power on.

☐ 22. Position gun so that the cable conduit between the wire feeder and gun is straight.

Note: Use the wire-inch for the following adjustment because it will help keep from shorting out the gas diffuser.

☐ 23. Turn the wire-inch on and feed the wire through the cable conduit to the gun while testing tension on the feed roller with the following procedures:

  ☐ a. Pinch the wire with finger pressure just ahead of the insulated input guide.

  ☐ b. If a slight pinching pressure will stop the wire from feeding through, the tension is probably all right.

  ☐ c. If a slight pinching pressure will not stop the wire from feeding through, the tension is probably too much.

☐ 24. Turn off power supply and wire feed supply, then replace the contact tip required for the size wire you are using, then snug the contact tip with pliers carefully.

☐ 25. Replace nozzle over contact tip. Drive rolls and contact tip must match the diameter of the wire.

☐ 26. Have your instructor check your work.

Note: The procedure for replacing a coil-type wire reel is essentially the same as a spool-type reel except that the coil-type reel has a spring-loaded device to secure and release it so that the reel separates into two halves in order for a replacement coil to be installed.

☐ 27. Adjust machine for specified welding activity.

☐ 28. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 19

Job Sheet 2—Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Ground placement	______
• Electrical adjustments	______
• Electrode extension	______
• Test bead quality	______
• Shut down procedure	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Screwdriver and adjustable wrench
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Procedure

☐ 1. Attach ground to workpiece and make sure that there is good metal-to-metal contact, and turn on shielding gas if applicable.

☐ 2. Turn machine on and adjust to correct polarity.

☐ 3. Set inductance and slope on zero if the machine is equipped with these controls.

☐ 4. Adjust voltage and wire feed to approximate settings for wire size and plate thickness as directed by your instructor.

☐ 5. Check allowable gun amperage to make sure it is high enough to handle amperage recommended for wire.

☐ 6. Place wire in machine and feed wire through contact tip as previously outlined.

☐ 7. Place a scrap metal workpiece on the work table.

☐ 8. Turn wire-feed power on, if applicable.

☐ 9. Inch the electrode out to the extension recommended for the wire size.

☐ 10. Position the tip of the electrode just off or just barely touching the workpiece.

☐ 11. Squeeze the trigger to start the arc, but do not push the electrode into the workpiece as the electrode starts to burn away.

☐ 12. Allow the arc to fully establish itself, then slowly pull the gun back until the recommended stickout is established.

☐ 13. Release the trigger to break the arc.

☐ 14. Make adjustments as needed to correct voltage and amperage settings.

☐ 15. Run a test bead on the piece of scrap metal to check for proper bead shape, spatter, penetration.

☐ 16. Clean the test bead with a chipping hammer and wire brush.

☐ 17. Inspect the bead visually for good bead shape and penetration or problems with spatter or porosity.

☐ 18. Make corrections as required.

☐ 19. Repeat procedure until settings are proper and bead has good appearance.

☐ 20. Chip and brush each bead.

☐ 21. Have your instructor check your work.

☐ 22. Turn off feed control power switch, if applicable.

☐ 23. Turn off welding machine power supply, and gas supply, if applicable.

☐ 24. Store gun, cable assembly, and ground clamp in a safe place.

☐ 25. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 20

Job Sheet 3—Prepare Mild Steel for FCAW

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment safety	______
• Workpiece preparation	______

Basic Skills

Reading

Critical Thinking

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Mild steel as selected by instructor
- Portable grinder and sanding attachment
- Cleaner/deoxidizer solution
- Pliers, clamps, and wire brush
- Clean shop rags
- Personal safety clothing and safety glasses

Procedure

☐ 1. Secure workpiece with pliers or clamps.

☐ 2. Remove mill scale, rust, dirt, and paint from all surfaces with portable sander.

☐ 3. Grind edges of joints for specified edge preparation.

☐ 4. Wire brush as required.

☐ 5. Have instructor check your work.

☐ 6. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 21

Job Sheet 4—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

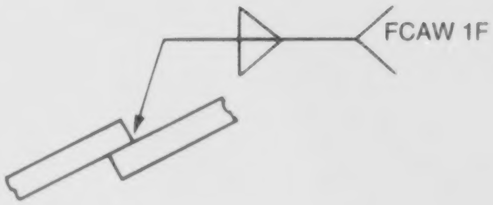
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection

5. Visible electrode extension: Per electrode selection
6. Position: 1F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

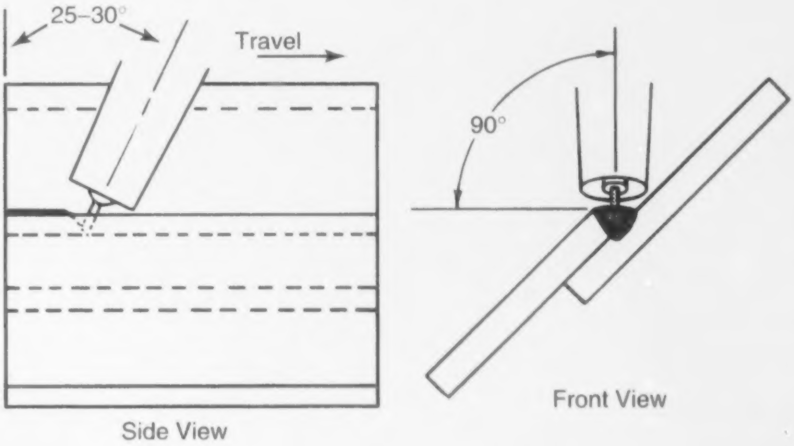
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates at a 45° angle.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 22

Job Sheet 5—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

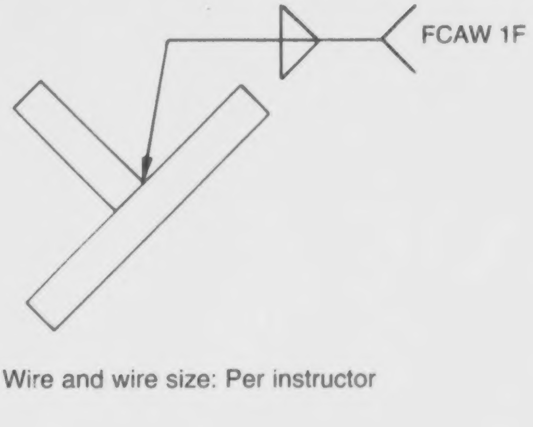
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor

3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 1F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

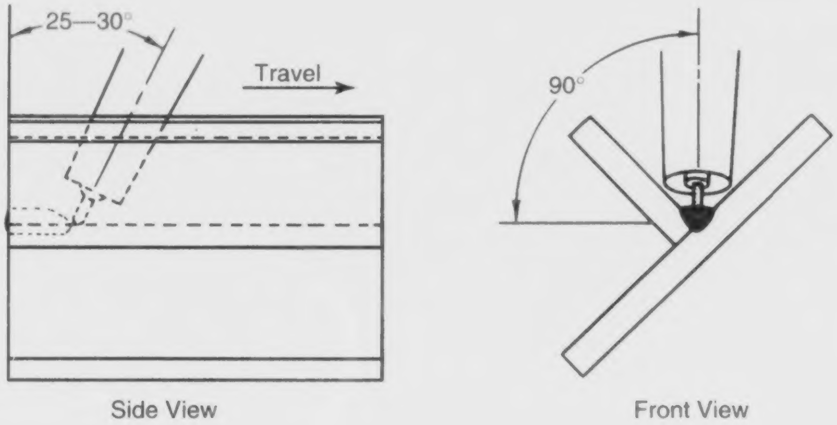
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates at a 45° angle.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Side View Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

Note: Fillet weld should have equal legs.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 23

Job Sheet 6—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

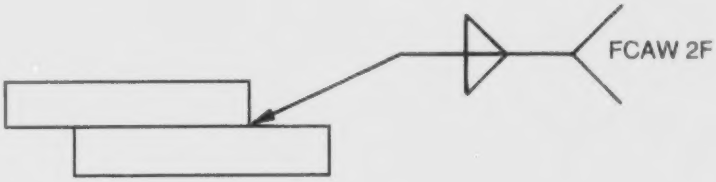
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection

5. Visible electrode extension: Per electrode selection
6. Position: 2F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

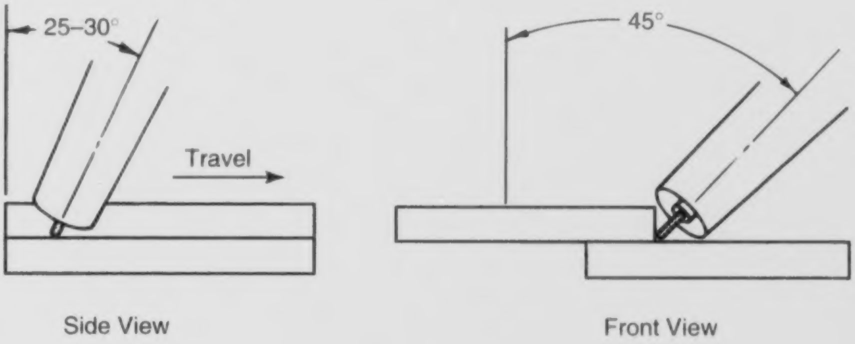
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld. Weld opposite joint using same procedure.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 24

Job Sheet 7—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	____
• Electrode extension	____
• Welding technique	____
• Crater and fill technique	____
• Cleaning and inspection	____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

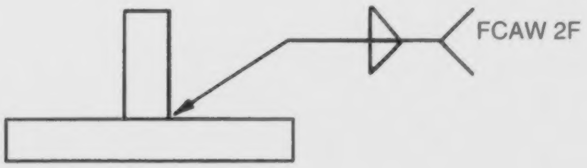
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection

6. Position: 2F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

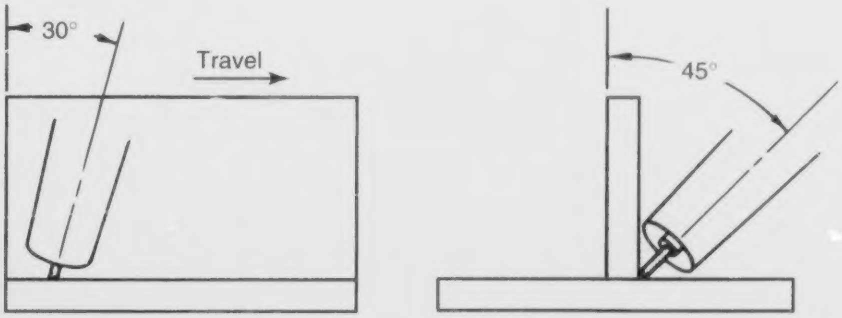
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in horizontal welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

Note: Fillet weld should have equal legs.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 25

Job Sheet 8—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

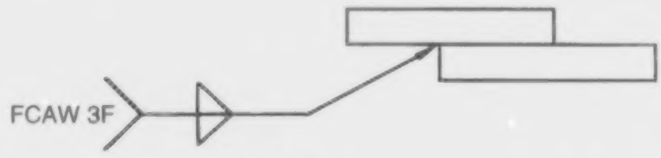
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



Top View

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection

5. Visible electrode extension: Per electrode selection
6. Position: 3F
7. Direction of welding: Vertical
8. Technique: Push
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

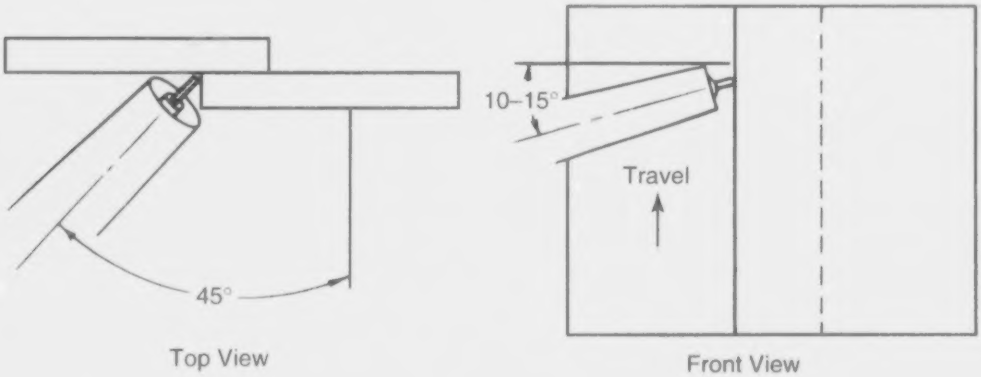
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in vertical position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Top View

Front View

☐ 8. Squeeze gun trigger and use push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

- ☐ 9. Crater and fill to end the weld and put gun in safe place.
- ☐ 10. Clean joint with chipping hammer and wire brush.
- ☐ 11. Inspect weld visually.
- ☐ 12. Have your instructor check your work.
- ☐ 13 Shut down and secure equipment.
- ☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 26

Job Sheet 9—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

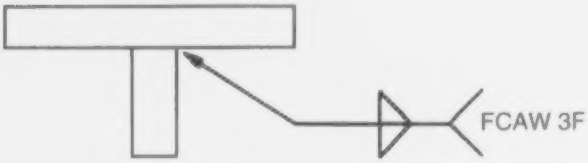
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



Top View

2. Wire and wire size: Per instructor

3. Voltage/wire feed: To recommended setting

4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3F
7. Direction of welding: Vertical
8. Technique: Push
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

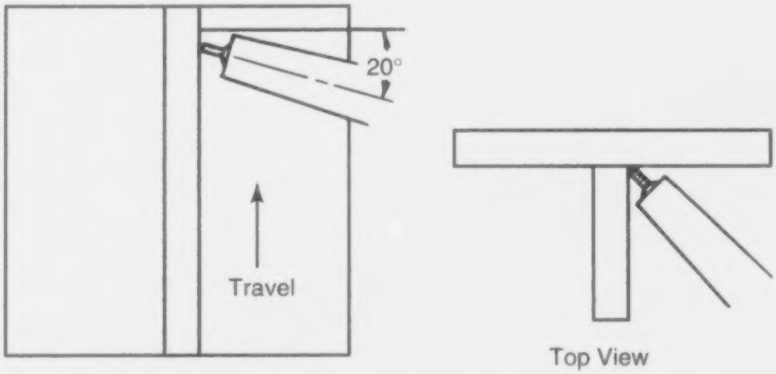
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in vertical position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Front View

Top View

☐ 8. Squeeze gun trigger and use push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

Note: Fillet weld should have equal legs.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 27

Job Sheet 10—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

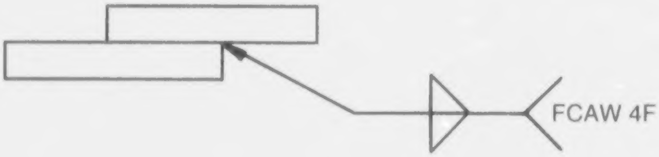
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection

5. Visible electrode extension: Per electrode selection
6. Position: 4F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

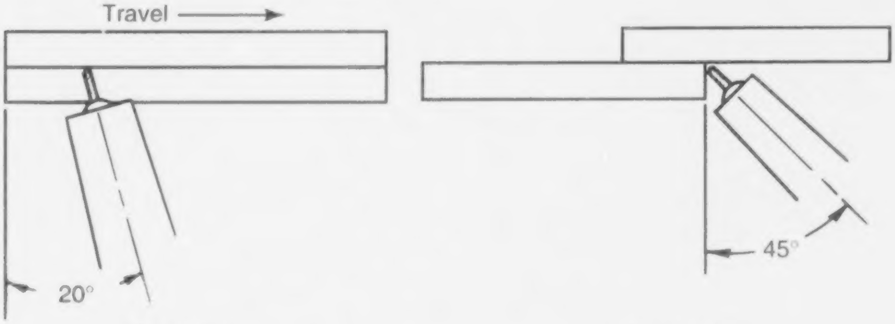
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in overhead welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Shut down and secure equipment.

☐ 14. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 28

Job Sheet 11—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Equipment setup and adjustments	______
• Electrode extension	______
• Welding technique	______
• Crater and fill technique	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

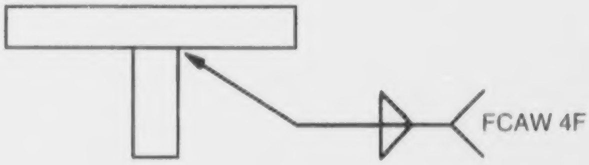
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection

5. Visible electrode extension: Per electrode selection
6. Position: 4F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

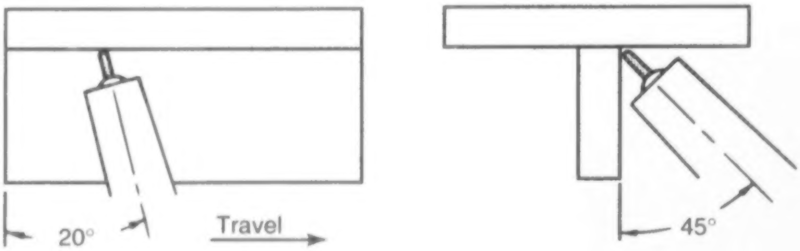
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in overhead welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.

Figure 2



Side View

Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

Note: Fillet weld should have equal legs.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 29

Job Sheet 12—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Joint preparation	_____
• Equipment setup and adjustments	_____
• Positioning and use of backup strip	_____
• Welding technique	_____
• Crater and fill technique	_____
• Fill-up bead application	_____
• Cap pass application	_____
• Cleaning and inspection	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: At instructor's discretion, V-groove butt joint can be welded with open root. Fitup and root weld will differ from backup strip.

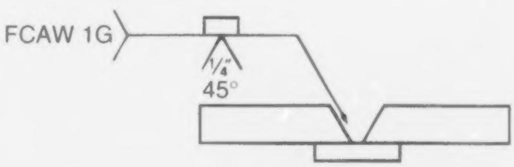
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Minimum of 1/4" mild steel backup strip
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Two "C" clamps
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 1G
7. Technique: Weave
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Prepare plates with 22 1/2° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

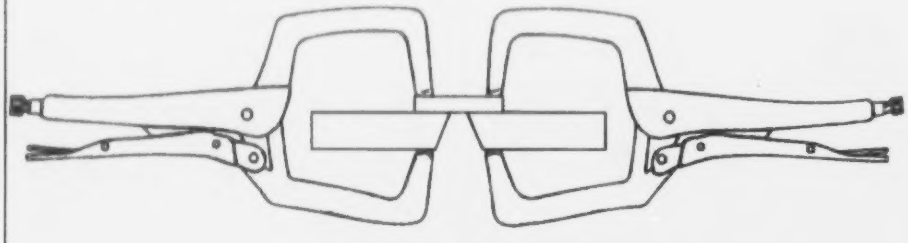
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a 1/4″ minimum thickness and long enough so that it extends 1″ beyond each edge of the joint to serve as a run-off tab.

☐ 7. Position plates on a work table so that there is a 1/4″ root opening in the joint.

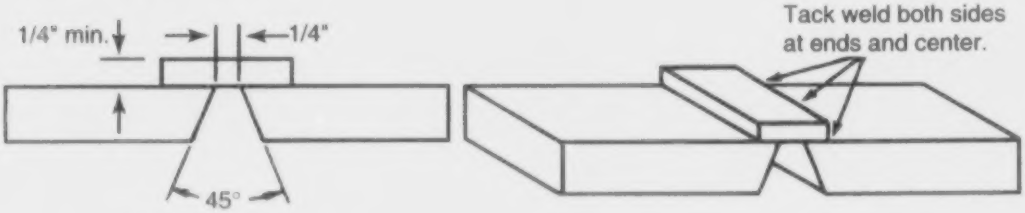
☐ 8. Place the backup strip in place and clamp it in place with two "C" clamps.

Figure 2



☐ 9. Tack weld the backup strip to the plates at both ends and in the center.

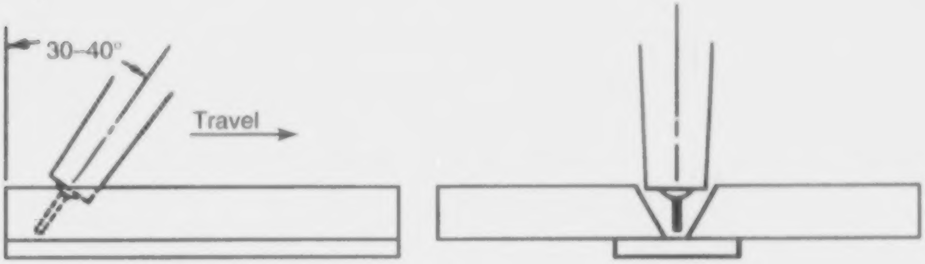
Figure 3


1/4" min.
1/4"
45°
Tack weld both sides at ends and center.

☐ 10. Position the joint and weld in the flat position.

☐ 11. Position gun at correct angle and check visible electrode extension.

Figure 4

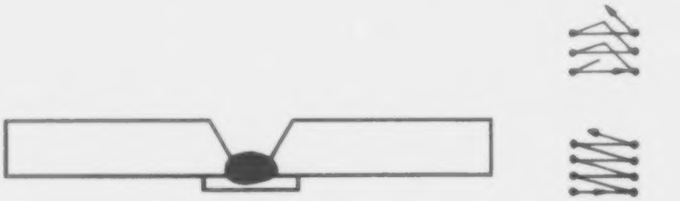

30–40°
Travel

Side View

Front View

☐ 12. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.

Figure 5


Weaving technique can vary.

☐ 13. Crater and fill to end the weld and put gun in safe place.

☐ 14. Clean with chipping hammer and wire brush.

☐ 15. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 16. Have your instructor check your work.

☐ 17. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 18. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 19. Crater and fill to end the weld and put gun in a safe place.

☐ 20. Clean and inspect second bead.

☐ 21. Have your instructor check your work.

☐ 22. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 23. Have your instructor check your work.

☐ 24. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 25. Reposition gun and use a weaving or stringer technique again to place a cap pass on the joint.

☐ 26. Clean and inspect cap pass and have your instructor check your work.

☐ 27. Put gun in a safe place.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's Comments: ____________________

____

____

Objective 30

Job Sheet 13—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Joint preparation	______
• Equipment setup and adjustments	______
• Positioning and use of backup strip	______
• Welding technique	______
• Crater and fill technique	______
• Fill-up bead application	______
• Cap pass application	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: At instructor's discretion, V-groove butt joint can be welded with open root. Fitup and root weld will differ from backup strip.

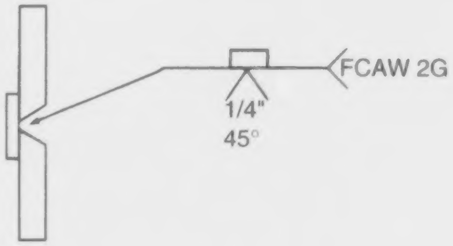
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Minimum of 1/4" mild steel backup strip
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Two "C" clamps
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 2G
7. Technique: Weave
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Prepare plates with 22 1/2° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

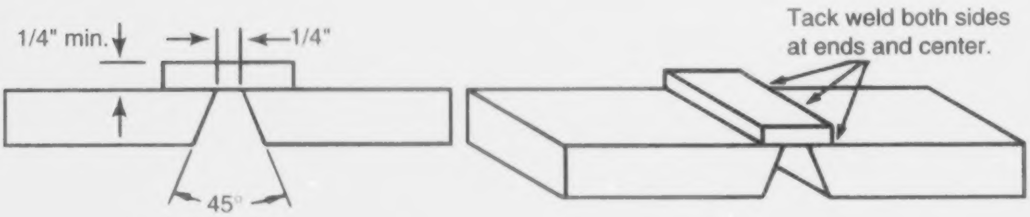
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a 1/4" minimum thickness and long enough so that it extends 1" beyond each edge of the joint to serve as a run-off tab.

☐ 7. Assemble beveled plates and backing strips so that there is a 1/4" root opening in the joint.

☐ 8. Use "C" clamps as required to secure the joint and backing, and tack weld the backup strip to the plates at both ends and in the center.

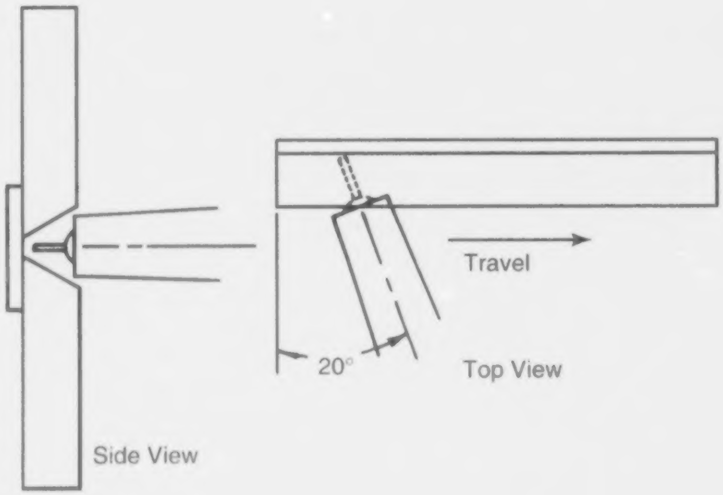
Figure 2



☐ 9. Position the joint and weld in horizontal position.

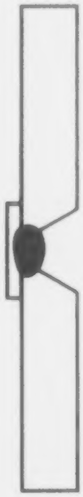
☐ 10. Position gun at correct angle and check visible electrode extension.

Figure 3



☐ 11. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.

Figure 4



☐ 12. Crater and fill to end the weld and put gun in safe place.

☐ 13. Clean with chipping hammer and wire brush.

☐ 14. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 15. Have your instructor check your work.

☐ 16. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 17. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 18. Crater and fill to end the weld and put gun in a safe place.

☐ 19. Clean and inspect second bead.

☐ 20. Have your instructor check your work.

☐ 21. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 22. Have your instructor check your work.

☐ 23. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving or stringer technique again to place a cap pass on the joint.

☐ 25. Use a stair-step technique to lay additional passes to reach the upper edge.

☐ 26. Clean and inspect cap pass and have your instructor check your work.

☐ 27. Put gun in a safe place.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 31

Job Sheet 14—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Joint preparation	______
• Equipment setup and adjustments	______
• Positioning and use of backup strip	______
• Welding technique	______
• Crater and fill technique	______
• Fill-up bead application	______
• Cap pass application	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: At instructor's discretion, V-groove butt joint can be welded with open root. Fitup and root weld will differ from backup strip.

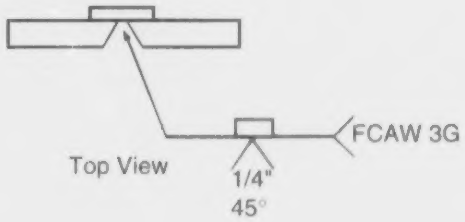
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Minimum of 1/4" mild steel backup strip
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Two "C" clamps
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3G
7. Direction of welding: Vertical
8. Technique: Weave
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: N/A

Procedure

☐ 1. Prepare plates with 22 1/2° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

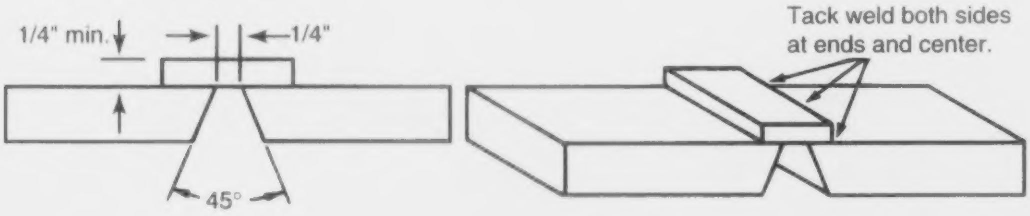
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a 1/4" minimum thickness and long enough so that it extends 1" beyond each edge of the joint to serve as a run-off tab.

☐ 7. Assemble beveled plates and backing strips so that there is a 1/4" root opening in the joint.

☐ 8. Use "C" clamps as required to secure the joint and backing, and tack weld the backup strip to the plates at both ends and in the center.

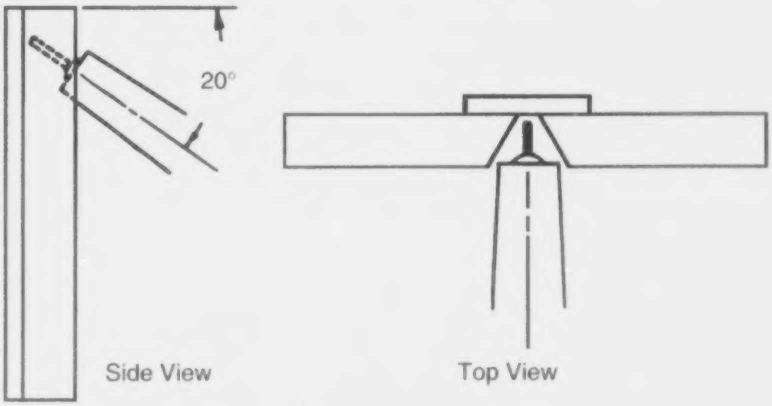
Figure 2



☐ 9. Position the joint and weld in vertical position.

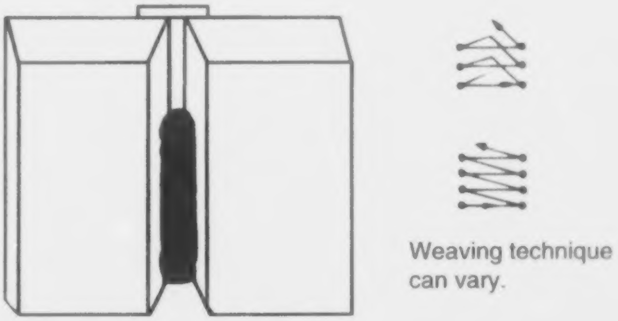
☐ 10. Position gun at correct angle and check visible electrode extension.

Figure 3



☐ 11. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.

Figure 4



☐ 12. Crater and fill to end the weld and put gun in safe place.

☐ 13. Clean with chipping hammer and wire brush.

☐ 14. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 15. Have your instructor check your work.

☐ 16. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 17. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 18. Crater and fill to end the weld and put gun in a safe place.

☐ 19. Clean and inspect second bead.

☐ 20. Have your instructor check your work.

☐ 21. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 22. Have your instructor check your work.

☐ 23. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving or stringer technique again to place a cap pass on the joint.

☐ 25. Clean and inspect cap pass and have your instructor check your work.

☐ 26. Put gun in a safe place.

☐ 27. Shut down and secure equipment.

☐ 28. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____

Objective 32

Job Sheet 15—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Joint preparation	______
• Equipment setup and adjustments	______
• Positioning and use of backup strip	______
• Welding technique	______
• Crater and fill technique	______
• Fill-up bead application	______
• Cap pass application	______
• Cleaning and inspection	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: At instructor's discretion, V-groove butt joint can be welded with open root. Fitup and root weld will differ from backup strip.

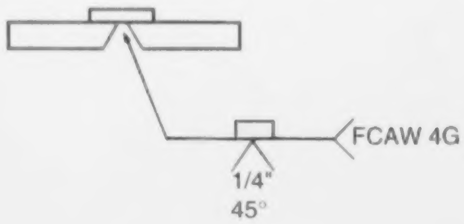
Tools, equipment, and materials

- FCAW machine with accessories
- FCAW wire as selected by instructor
- Mild steel as selected by instructor
- Minimum of 1/4" mild steel backup strip
- Wire-cutting pliers and file
- Chipping hammer and wire brush
- Two "C" clamps
- Personal safety clothing and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 4G
7. Technique: Weave
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

Procedure

☐ 1. Prepare plates with 22 1/2° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

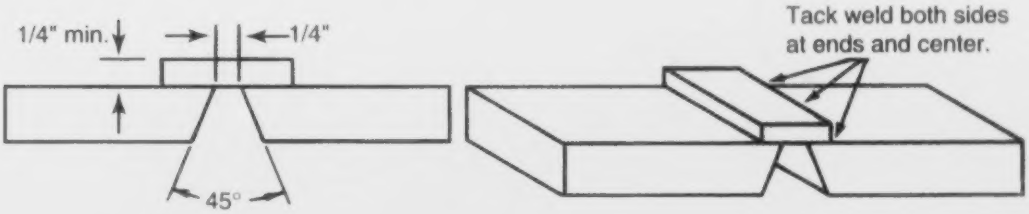
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a 1/4″ minimum thickness and long enough so that it extends 1″ beyond each edge of the joint to serve as a run-off tab.

☐ 7. Assemble beveled plates and backing strips so that there is a 1/4″ root opening in the joint.

☐ 8. Use "C" clamps as required to secure the joint and backing, and tack weld the backup strip to the plates at both ends and in the center.

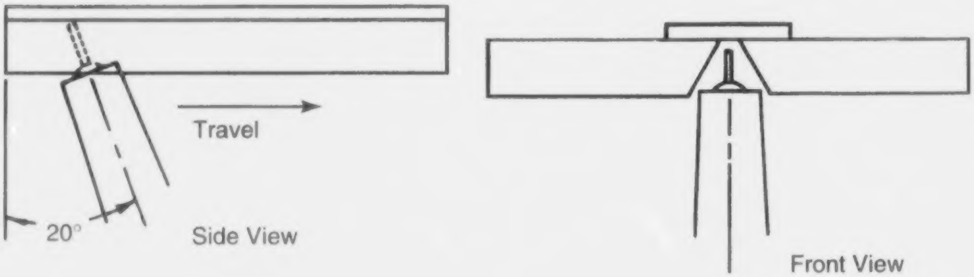
Figure 2



☐ 9. Position the joint and weld in the overhead position.

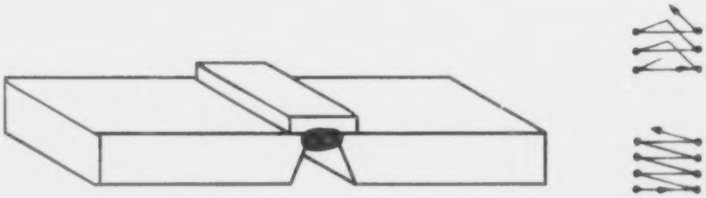
☐ 10. Position gun at correct angle and check visible electrode extension.

Figure 3



☐ 11. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.

Figure 4


Weaving technique can vary.

☐ 12. Crater and fill to end the weld and put gun in safe place.

☐ 13. Clean with chipping hammer and wire brush.

☐ 14. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 15. Have your instructor check your work.

☐ 16. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 17. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 18. Crater and fill to end the weld and put gun in a safe place.

☐ 19. Clean and inspect second bead.

☐ 20. Have your instructor check your work.

☐ 21. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 22. Have your instructor check your work.

☐ 23. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use the stringer technique again to place a cap pass at the edge of the groove, then overlap passes to the other edge.

☐ 25. Clean and inspect cap pass and have your instructor check your work.

☐ 26. Put gun in a safe place.

☐ 27. Shut down and secure equipment.

☐ 28. Check in tools and materials and clean area.

Evaluator's Comments: ______________________________

____

____